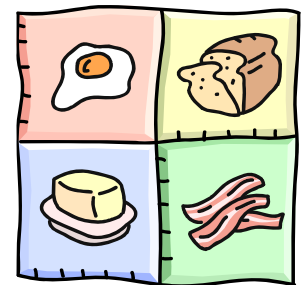
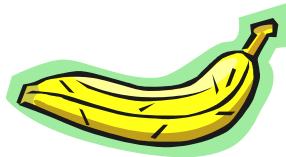




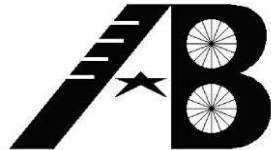
Essentials of
Nutrition for Sports

Arnie Baker, MD



Essentials of *1st Edition*
Nutrition for Sports

Arnie Baker, MD



<http://arniebakercycling.com>

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*A free supplement to this book is available at:
<http://roadbikerider.com/nutritionforsportssupplement.htm>.
 It contains the following parts:*

Body Fat, Weight

Healthy Fast Food

USDA & FDA Basics

**Vitamins, Minerals, and Other
 Nutrients**

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Coach and Author

Arnie Baker, MD

Dr. Arnie Baker has been coaching since 1987. A professional, licensed USCF coach, he has coached racers to several Olympic Games, more than 120 US National Championships, and 35 US records. He is and has been the only National Cycling Coach for Team in Training. This endurance-training program of more than 800 coaches and 30,000 participants raises more than \$80,000,000 each year for the Leukemia & Lymphoma Society.

Arnie has a Category 1 USCF racing license. He has held eight US 40-K time-trial records, has won multiple national championships, and has won more than 200 races. An all-round racer, he was the first to medal in every championship event in his district in a single year.

Dr. Baker is a licensed physician in San Diego, California. He obtained his MD as well as a master's degree in surgery from McGill University, Montreal. He is a board-certified family practitioner. Before retiring to ride, coach, and write, he devoted approximately half of his medical practice to bicyclists. He has served on the fitness board of *Bicycling* magazine as a bicycling-physician consultant. He has been a medical consultant to USA Cycling and the International Olympic Committee.

Arnie has authored or co-authored 17 books and more than 1,000 articles on bicycling and bicycling-related subjects.

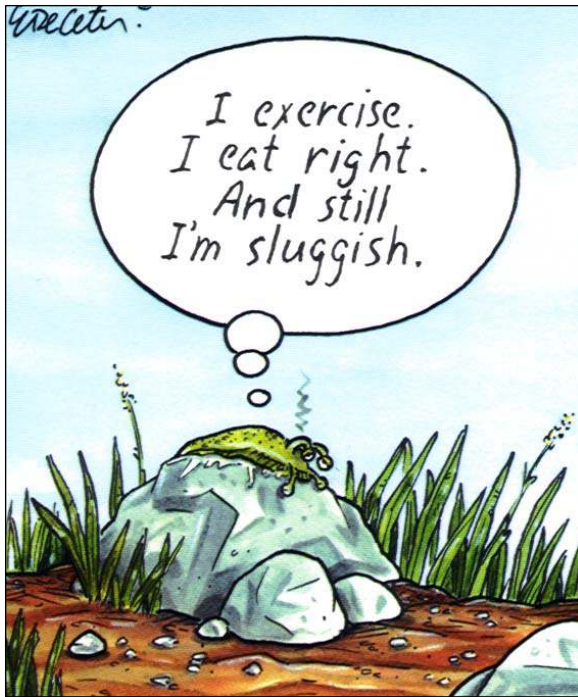
Also by Arnie Baker, MD:

- Altitude Climbing Endurance (ACE) Training for Cyclists
- Bicycling Medicine—Cycling Nutrition, Physiology and Injury Prevention, and Treatment
- Bike Fit
- High-Intensity Training (HIT) for Cyclists
- Psychling Psychology: Mind Training for Cyclists
- Skills Training for Cyclists
- Smart Coaching
- Smart Cycling—Successful Training & Racing
- Strategy & Tactics for Cyclists
- The Essential Cyclist

Help, But No Guarantees

I used special diets, vegetarian diets with lots of vitamins. Then I'd see the East Germans gorging themselves on greasy French fries and Wiener schnitzel then go out on the track and set world records. It makes you wonder about diet.

—Mark Gorski. Olympic Gold Medalist, Cycling.



nu-tri-tion (nū-trīsh'ən) *n.*¹

1. The process by which a living organism assimilates food and uses it for growth, liberation of energy, and replacement of tissues; its successive stages include digestion, absorption, assimilation, and excretion.
2. The science or study that deals with food and nourishment, especially in humans.

Nutrition can help, but it is not everything.

Athletes sometimes ascribe magical powers to nutrition, believing that if they just “get it right,” performance will zoom and fitness will be transformed.

Good nutrition can help performance. Poor nutrition can *worsen* performance. There is no guarantee, either way. Many athletic health gurus have died early.²

Just as athletes sometimes have unrealistic expectations about the importance of nutrition, so does the general population. Eating healthily or “health foods” does not result in immortality. It is possible to drink heavily, be morbidly obese and yet live a long life.

It is all about risk and odds. Healthy nutrition does lower the risk of cancer, heart disease, and a host of other diseases. Further, for the years we do have, it helps many of us live stronger.

¹ Stedman's Medical Dictionary, 2002 by Houghton Mifflin Company.

² To name just three: runner Jim Fixx, PowerBar founder Brian Maxwell, bicycling nutrition guru Ed Burke.

Read Me First—Forward

There is a lot of information in this book. The first parts provide important information for you to use right away—the next time you train. Other parts are best used as reference.

Here are some training essentials:

- Replace fluids.
- Consume calories while exercising.
- If exercising for many hours, pay attention to sodium.
- Avoid multiple or costly supplements.
- Almost always, avoid so-called ergogenics.

Here is what you will find in the different parts of this book:

Nutrition Quiz. A fun start. If you get all the questions right, maybe you do not need to read the rest of the book!

Part 1. Workout & Event Nutrition. The practical aspects of endurance sports nutrition.

Part 2. Calories. A mix of the practical with basic science, helping you understand *why* recommendations are made.

Part 3. Sports Foods. Lists of representative sports nutritional products. Once you understand what is in these products, you may be more confident about using “real foods” or other options.

Part 4. Ergogenics and Ergolytics. This part is all about the products that are sold to make you go fast—which, most of the time, do not. You will find a review of what is in the marketplace, and explanations about why, generally, it may not be worth spending your money or risking your health.

Part 5. Nutrition Promotion and Quackery. Education about how products are marketed, how to be a smart consumer, and about the dangers of nutritional quackery.

Key Points. A summary of the key points made throughout the book.

Nutrition for Sports Supplement

The supplement is published separately for ease of electronic transmission and manageable print volumes.

It is available as a free download at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

The supplement contains the following parts:

Part 6. Body Fat, Weight. Many endurance aerobic athletes strive to lose weight. You will find a review, not necessarily glamorous, of how to lose weight. You will also read how basically every diet you have read about as new is really a reincarnation of something previously promoted.

Part 7. Healthy Fast Food. Not an oxymoron. Sensible ideas for breakfasts and quick, low-calorie dinners, chock full of nutrients.

Part 8. USDA & FDA Basics. What is the food label about? What are the laws for advertising nutrition facts, daily values, nutrient content, and other health claims? What do the claims really mean?

Part 9: Vitamins, Minerals, and Other Nutrients. Read this when you have a lot of time, as reference material, or to help you understand the academic underpinnings of the more practical information about vitamins, minerals, and supplements presented throughout this book.

Thank you,

Arnie Baker

Nutrition Quiz

1. **T F** Protein is useful before athletic events. That is why you often hear about athletes having a steak breakfast.
2. **T F** Everyone needs vitamins. Athletes need so many to perform well that all athletes should take at least several supplemental vitamin pills.
3. **T F** Protein is important in building muscle. Athletes wanting to increase their strength need protein shakes or supplements.
4. **T F** Since the body's energy system runs on sugars, soft drinks and candy bars are ideal foods.
5. **T F** Since being light is so important in getting up hills, it helps to be a little dehydrated before hilly races.
6. **T F** Athletic drinks are required during all races for their nutritional superiority over plain water.
7. **T F** Wine or beer with your meal helps digestion.
8. **T F** If you are training for a long race, it helps to train without drinking. This helps to adapt your body for the effects of dehydration you can expect in the long race.
9. **T F** No harm comes from taking too many vitamins. It is better to be safe than sorry.
10. **T F** During heavy hot-weather exercise, do not forget to take extra manganese to prevent muscle cramps.
11. **T F** Athletes making claims for foods or vitamins usually do so because they believe in the product rather than for financial gain from endorsement.
12. **T F** If you eat right ("to keep fit") you will not get cancer or heart disease.
13. **T F** Vegetarians do not get enough protein or iron.
14. **T F** You should eat extra food at bedtime because your body digests it better when at rest while sleeping.
15. **T F** Raw unpasteurized milk is a "perfect food." Certainly, it is preferred to watery fat-free milk.
16. **T F** Your mother was wrong. Colored green and yellow vegetables really are not important. It is a myth that you need them.
17. **T F** Your mother was right. You should finish everything on your dinner plate.
18. **T F** Since it is primarily fats that are burned on long rides, fatty foods consumed during rides actually help performance.
19. **T F** When you are thirsty during a hot race, it is better to drink warm fluids—they are already closer to body temperature.
20. **T F** Diet pills or prescription diet medicines from a doctor should be used to lose weight.
- Bonus** A Girl Scout cookie has 7 grams of carbohydrate and 3 grams of fat. What percentage of its calories comes from fat?

Quiz Answers

Probably a lot more is not known about nutrition than is known. This area is subject to much mythology. All of the twenty T F questions are false or mostly false. The Girl Scout cookie in question has 7 grams of carbohydrate, for 28 calories, and 3 grams of fat, for 27 calories. Of a total 55 calories, 27 calories, or 49% come from fat.

General Nutrition Key Points

- Eat a variety of whole, unprocessed foods in moderation.
- Eat at least half a dozen servings of fruits and vegetables daily.
- Control your weight.
- Limit or avoid alcohol.
- Eat a diet relatively high in fiber.
- Eat fewer simple sugars—candy, table sugar, “sweets.”
- Avoid junk food.
- Avoid high-fat and high-cholesterol foods.
- Avoid salty foods (unless you will be sweating quarts).
- Rely on food, not pills.
- Consider a multivitamin/multimineral supplement.
- There are no absolute rules. Very different diets consumed by different people may have equal nutritional value and result in good nutrition. Occasional dietary indiscretions are not important.

Part 1:

Workout & Event Nutrition

Introduction

From the athletes' point of view, there is nutrition related to workouts and events, and general nutrition.

Nutrition related to workouts and events refers to nutrition before, during, and after workouts and events. It is about pre-exercise, during exercise, and post-exercise nutrition.

It is mostly about fluids and carbohydrate calories. It is a little about sodium.

Of course, caloric mix and quality, vitamins, minerals, and other nutrients have important roles to play in general or overall nutrition; these topics are covered throughout this book.

Workout Key Points

Pre Exercise

- Start exercise well-hydrated.
- Start exercise glycogen-loaded in both muscles and liver.
 - Supper: Pre-event meal high in carbohydrate. If planning to exercise for more than 4 hours, or 2 hours in high heat and humidity, add salt to foods.
 - Breakfast: Cyclists aim for at least 1,000 calories. Runners may not be able to eat as much-perhaps only a few hundred calories. Walkers and triathletes will be in between.
 - Pre-workout calories benefit both endurance and strength athletes, both aerobic and anaerobic work.
- Start prolonged exercise in the heat salt-loaded.
- Be prepared for start delays.
 - At the event: Have easily digestible fluids and calories available in case of a start delay.

During Exercise

- Hydrate
 - Aim for at least 8 ounces (250 milliliters) of fluids, every 15 to 30 minutes, depending upon the heat.
 - Have carbohydrate-in-water solutions (for example, maltodextrins or sports drinks), rather than plain water.
 - Cyclists: Carry two waterbottles. Or use a hydration system (for example, CamelBak). Walkers: Carry a waterbottle.
- Calories
 - For events longer than one hour, consume at least 300 calories per hour of exercise.
- Salt
 - For multi-hour events in conditions of heat and humidity, consume salty foods, and sodium-rich solutions and gels.

Post Exercise

- Refueling after exercise is a proven recovery strategy.
- The sooner the better. Refueling during exercise is best.
- Prompt refueling benefits both endurance and strength athletes.
- Prompt refueling benefits aerobic and anaerobic work.
- Aim to ingest at least 50 grams of carbohydrate (200 calories) within the first 30 minutes after exercise and again every hour for the next 3 hours, up to caloric deficit.
- Some fat and some protein with the carbohydrate is no problem.
- “Real food” is probably better than specialty sports products.

Pre-Exercise Nutrition

Key Points

- Start exercise well-hydrated.
- Start exercise glycogen-loaded in both muscles and liver.
 - Supper: Pre-event meal high in carbohydrate. If planning to exercise for more than 4 hours, or 2 hours in high heat and humidity, add salt to foods.
 - Breakfast: Cyclists aim for at least 1,000 calories. Runners may not be able to eat as much—perhaps only a few hundred calories. Walkers and triathletes will be in between.
 - Pre-workout calories benefit both endurance and strength athletes, both aerobic and anaerobic work.
- Start prolonged exercise in the heat salt-loaded.
- Be prepared for start delays.
 - At the event: Have easily digestible fluids and calories available in case of a start delay.

Hydration

Exercise can be dehydrating. It is best to start well-hydrated.

As discussed in the section on hydration beginning on page 27, intracellular hydration is different from vascular hydration. Drinking 16 to 32 ounces (500 to 1,000 milliliters) in the hour before a workout or event may improve vascular hydration, but may not improve intracellular hydration.

Intracellular hydration requires adequate hydration in the 24 to 48 hours before exercise.

Although athletes are often advised to drink 16 to 32 ounces in the hour before exercise to assure adequate hydration, this is not always the best strategy.

If you are already well-hydrated, and your workout or event does not allow for easy urination, you may not want to drink that much before exercise and be forced to race with a full bladder.

For example, if you are going to race a 20-kilometer (12.4-mile) bicycle time trial under temperate conditions, dehydration during the roughly 30-minute event is not likely. If you have kept up with losses up to the hour before your race start, drinking a full waterbottle (16 ounces, 500 milliliters) within 30 minutes of your race start is not likely to improve performance, and may worsen it.

On the other hand, keeping up with fluid losses, and drinking a bottle just before the start of a hot 2-hour hilly cycling road race makes sense, especially if fluids on route are limited, you are discrete, and you have the skills to urinate while riding.

Calories

You need fuel to work.

Starting hungry—calorically deficient—is a bad strategy.

If exercising at high intensity, you'd like your stomach empty. You do not want to have a heavy meal in the minutes before an all-out effort. This is especially true for runners.

On the other hand, if exercising for many hours at moderate or low intensity, solid food near the start time may be fine. This is especially true for cyclists.

Planning to ride a recreational century? The 100 miles will burn about 3,000 calories. By pacing, riding moderately at the start, it may be easy to have a few hundred calories of solid food just before the start.

Top Up Blood Sugar and Glycogen

For basal metabolism and exercise associated with warming up, you may use 250 calories per hour. Ingesting this amount of caloric energy in the hours before your workout or event may allow you to

keep glycogen levels in both liver and muscle high and prevent lowering of blood sugar levels at the start.

The closer to your hard workout or intense event start, the more you will rely on liquids, rather than solids, to provide calories.

Carbohydrate in solution may not be necessary for events as short as 30 minutes, although some studies have shown benefit even for events of this duration.

For workouts or events lasting an hour or longer, topping up energy supplies is important. The longer your event, the more important it is to start with a full tank.

Caloric Mix

Big meals and fatty meals ingested within an hour of intense exercise can cause performance problems. Fats delay the emptying of the stomach. When blood supplies are diverted to the intestines to aid digestion, less blood is available to go to the working muscles. Intestinal cramps may also result.

If you're entering a road race of 70 miles and it is not going to get "hot and heavy" until two hours or 50 miles into the race, a balanced meal, not based solely on carbohydrate, may stay with you longer, helping to mete out energy over the few hours of your event. Tour de France riders, for example, typically include fats and protein along with their pre-race carbohydrate meals.

Some foods may have the right caloric mix, but be hard to get down. For example, even if comprised mostly of carbohydrate, some energy bars may feel like balls of cardboard in the mouth and stomach.

Insulin and Low Blood Sugar Levels

When carbohydrate solutions are ingested 30 minutes before exercise, insulin levels may rise and blood sugar levels may fall immediately before exercise starts.

Depending upon type of sugar, formulation, and the exact timing of the sugar load, pre-exercise carbohydrate may also result in higher or lower blood sugar levels during the first 10 minutes of exercise. Even if blood sugar levels fall, studies generally show that performance is the same or improved.

Pre-event feedings have concentrated on carbohydrate calories. Feedings with medium-chain triglycerides have not been shown to improve performance.

Missing Breakfast?

Runners often race without breakfast; this is not a recommended strategy.

An evening meal with a high fat content may help, because liver glycogen stores may be relatively spared by the slower digestion and metabolism of fats and the resulting longer entry of nutrients from the gastrointestinal tract into the bloodstream.

Salt Loading

In general, it is probably best for good health to consume a diet relatively low in sodium.

If you are going to workout or race for several hours or more in the heat, it may be difficult to replace sodium during your exercise.

Adding a tablespoon of salt (6,600 mg sodium) to foods over the course of the 24 hours before your exercise may be a good strategy.

The best way to get extra sodium is by eating salty foods. The night before long workouts in the heat add some salt to your pasta meal or have high sodium foods such as pizza, pretzels, or soup. Tomato juice and V-8® are high-sodium fluids.

It is preferable to eat salty foods or drinks rather than ingest salt tablets. Studies have shown that salty foods and drinks appropriately stimulate thirst, and so prevent the unintentional ingestion of dangerously high amounts of sodium.

Read more about sodium, including sweat losses during events, on page 17 and page 21.

Read more about sodium after events on page 20.

Read more about sodium, including the sodium content of selected foods, starting on page 162.

Keep Pre-Event Supplies Handy

Start delays of several hours or longer may occur because of event permitting problems, weather delays, or roadwork problems. Be prepared to keep fluids, calories, and even salt levels high, with a cooler stocked with solids and liquids. Be prepared for short delays with easily digestible supplies. Be prepared for substantial delays with “real food.”

Nutrition While Exercising

Key Points

- Hydrate
 - Aim for at least 8 ounces (250 milliliters) of fluids, every 15 to 30 minutes, depending upon the heat.
 - Have carbohydrate-in-water solutions (for example, maltodextrins or sports drinks), rather than plain water.
 - Cyclists: Carry two waterbottles. Or use a hydration system (for example, CamelBak). Walkers: Carry a waterbottle.
- Calories
 - For events longer than one hour, consume at least 300 calories per hour of exercise.
- Salt
 - For multi-hour events in conditions of heat and humidity, consume salty foods, and sodium-rich solutions and gels.

Summary Table

	30 Min	60 Min	2 Hr	5 Hr	12 Hr	24 Hr	Multi-day
Fluids		X	XX	XXX	XXX	XXX	XXX
Carb cals/hour		X	300	300	300	300	500
Sodium			X	XX	XXX	XXX	XXX
Vitamins						X	XX
Weigh-in						X	XXX

Table 1. Nutrition while exercising concerns and calorie goals per hour. X=minor concern. XXX=major concern.

What We're Talking About

Consider for a moment a typical American workday: You work three hours in the morning, have a 15-minute coffee break, take 30 to 60 minutes for lunch, and work for four hours in the afternoon, with another 15-minute break. You consume 500 calories for breakfast and 1,000 calories during lunch and work breaks. You drink many glasses of water, coffee, or other fluids.

Doesn't it make sense that when you are exercising, you need even more calories and water? Of course! —Yet so many of us train or race until we drop without drinking enough and fueling our bodies.

The priorities for nutrition during endurance cycling, running, triathlons, or walking are water, calories, and sodium.

For events under an hour, no special nutrition may be needed.

For most events over an hour, concern yourself mainly with fluids and calories.

For long-distance events over most of a day or longer, also consider sodium.

Nutrition Losses

Fluid Loss

Fluid is lost primarily in the urine and through sweating. The kidneys have a tremendous ability to dilute or concentrate urine. They can rid the body of large excesses of fluids when the need arises. They can also concentrate urine if a person becomes dehydrated.

Sweat rate depends upon work rate and climate (heat and humidity). During hard work in hot desert-like conditions, it is possible to lose more than a couple of quarts (liters) per hour. Sweat rates have been measured up to 3.5 quarts per hour and 17 quarts per day.

For events longer than one hour, or one-half hour in the heat, water replacement is important. Although carbohydrate or electrolytes may not be necessary for energy or balancing mineral losses, they aid hydration by increasing the rate of water uptake by the gastrointestinal tract. They also increase palatability: Fluids that taste better encourage drinking. Chilled fluids also help encourage drinking and are absorbed more quickly.

Aim for 8 ounces of fluids every 15 minutes in the heat. That is about one quart (liter) every hour. Although you may lose more, it is doubtful that drinking more will be helpful because your body probably cannot process more than that. (With nutritional training, athletes learn to tolerate up to 12 ounces every 15 minutes.)

During road racing events, most cyclists and walkers *must* carry waterbottles or hydration systems (for example, CamelBak)—the time distance between aid stations is too great to rely on them for hydration. In addition, walking events often run out of fluids at aid stations. (Runners do not exercise as long, and for them the time distance between aid stations may be short enough so that waterbottles are not required.)

During 40-K cycling time trials, many racers do not bring waterbottles, even in desert events. During races at maximum effort—although dehydration worsens performance slightly—the disruption of rhythm, the time cost of drinking and the aerodynamic cost of water bottles usually justify not drinking.

Read more about hydration in the chapter on hydration starting on page 27.

Calorie/Energy Loss

Calorie/Energy Loss

It is typical to use 2,500 to 3,000 calories during a cycling century (one-hundred miles); twice as much in a double century or

an ACE event (one-day altitude climbing, endurance events over 100 miles with more than 10,000 feet of climbing).

Runners and walkers use about 80 calories per mile.

Energy loss depends upon work rate. Work rates may be up to 1,200 calories per hour.

In ultra-distance events, work rates are reduced, but duration—the number of hours of work—is increased. It is possible for a 200⁺-pound rider cycling 24 hours in a day to burn 15,000 calories. The typical daily energy requirement of a 150-pound racer cycling 22 hours per day is 10,000 calories. Most multi-day ultra-distance riders become calorically deficient, consuming about 85% of their daily energy expenditure.

For more information about estimating caloric expenditure for basal metabolism and exercise, see page 35.

Some of this energy comes from the body's stores of carbohydrate (glycogen) and fat. Some energy needs can be met by consuming calories while exercising. Depending upon your size, your body can use up to 300 ingested carbohydrate calories per hour (about 1 gram per kilogram per hour). As a rule, try to consume this many calories for every hour you exercise. Multiple studies confirm that athletes perform better when they fuel while exercising. Calories can come from solids, gels, or solutions.

Do you need protein or fat during exercise? Studies have not shown this to be true. (Consume your requirements during the course of the day, not necessarily during exercise.) Read more about protein and recovery on page 66.

The harder you work, the less you are able to tolerate solid food. Cyclists are able to eat solid food while exercising. Most runners cannot.

Although studies show that gels are generally less palatable than carbohydrate solutions, some athletes prefer gels.

Carbohydrate solutions are a convenient way to get calories. Typical sports drinks and diluted fruit juice have 100–125 calories per 16-ounce (500 milliliter) bottle.

More than 400 calories per bottle can be obtained and tolerated with a few specialty sports drinks that contain glucose polymers or maltodextrins. Examples of these products include Extran and Carbo Gain. Read more about maltodextrins on page 51.

Energy bars and gels do work, but after many hours become tiresome for most athletes. If not racing, cyclists do well to stop periodically and eat “real food” —especially early on in a long ride. Leftover breakfast items such as French toast or pancakes, fig bars, bananas, and Pop-Tarts (perfectly packaged for jersey pockets) are favorites for short stops.

Walkers may take short breaks for bananas or other solids.

Runners do not tend to exercise as long and rely more on carbohydrate gels.

Train to Eat

Although it may not be necessary to consume calories during shorter training sessions, it is crucial in long-distance events. You must practice eating, even in shorter training sessions, to allow your gastrointestinal tract to adapt to the process of eating while exercising.

Minerals

Sodium is the electrolyte priority for the aerobic endurance athlete.

For an analysis of the possible needs of other minerals found in sweat, see page 21.

Sodium

A low concentration of sodium in the blood is associated with weakness, fatigue, seizures, and occasionally death.

The body loses about one gram of sodium per quart (liter) of sweat. After a gallon (4 quarts, 4 liters) of such loss, the average total daily intake of sodium may be inadequate to meet demands, and the blood sodium may drop.

In temperate weather conditions, this may take 4 or 5 hours. In high heat conditions, sodium depletion can occur in just a couple of hours.

For aerobic-endurance athletes, it is reasonable to plan on an intake of up to a maximum of one gram (1,000 milligrams) of sodium per liter of fluid loss. This is about one-half teaspoon of salt.

Salt in beverages is often unpalatable.

Salty-snacks, including low-fat pretzels, saltines, and pickles are often a good choice for athletes at rest stops.

Carry salt and sprinkle it on oranges or cantaloupe slices.

Read more about sodium before events on page 14.

Read more about sweat losses during events on page 21.

Read more about sodium after events on page 20.

Read more about sodium, including the sodium content of selected foods, starting on page 162.

Weigh-In/Diet Diary/Lab Chemistry

For all-day or multi-day events, repeated, accurate weight measurement can help determine hydration status. Scales accurate to 0.1 pound or kilogram are best.

Some weight loss will reflect glycogen depletion. Read more about acute weight changes in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

For multi-day events—for example, the Race Across America—a support crew member charged with recording solids and liquids ingested and eliminated can help evaluate caloric, fluid, and mineral balance.

Spot checks of urine electrolytes and specific gravity, or blood biochemistries are occasionally used by sophisticated crews in multi-day events.

Keep Event Supplies Handy

In events over several hours or longer, most athletes do not eat or drink enough. Athlete nutritional intake is heavily dependent upon what the organizer provides at aid stations. Carb, fluid and sodium replacement is often inadequate to keep up with demands. Plan on personal support unless your event is well-provisioned.

Post-Exercise Nutrition

Key Points

- Refueling after exercise is a proven recovery strategy.
- The sooner the better. Refueling during exercise is best.
- Prompt refueling benefits both endurance and strength athletes.
- Prompt refueling benefits aerobic and anaerobic work.
- Aim to ingest at least 50 grams of carbohydrate (200 calories) within the first 30 minutes after exercise and again every hour for the next 3 hours, up to caloric deficit.
- Some fat and some protein with the carbohydrate is no problem.
- “Real food” is probably better than specialty sports products.

Hydration

Replace fluids lost during exercise.

Read more about hydration in the chapter on hydration starting on page 27.

Calories

Glycogen Window

The glycogen window refers to the concept that a post-exercise window of opportunity exists when ingested carbohydrate can be converted to muscle glycogen more readily than at a later time.

Replacing carbohydrate as soon as possible after exercise may reload glycogen to a greater extent than if you travel home, shower, and then sit down to a meal.

On average, the body can incorporate about 50 grams (200 calories) of carbohydrate into glycogen per hour in the first few hours after exercise—if carbohydrate is available.

Despite advertising hype, protein has not been shown to improve glycogen reloading. For more information about protein and recovery, see page 66.

That is not to say that protein is not important in your overall daily program, or that it is bad for recovery. Protein may be helpful for other reasons, discussed below.

Caveats

Dietary patterns (high carbohydrate, low fat vs. lower-carbohydrate, higher-fat) may not degrade training when workout intensity is low to moderate.

If you have 48 hours to recover before your next high-intensity workout—that is, a rest day in between—you have more time to replace glycogen. A lower-carbohydrate, higher-fat diet may not decrease performance.

Fat Window

The glycogen window is relatively well-studied. The fat window is less-well understood. (The glycogen was easier to study and was examined first.)

About 1,500 calories are stored in muscle for energy use as glycogen. About 2,500 calories are stored for energy use as intramuscular lipid.

Fat replacement after exercise has been shown to effectively restore intramuscular lipid using water-suppressed nuclear magnetic resonance spectroscopic imaging.

If you do not get enough fat in your diet, muscle glycogen stores may be great, but muscle fat stores may be deficient. Aerobic endurance exercise demands both to perform well.

How much fat is needed and how quickly is unknown. Whether carbohydrate can be converted to intramuscular fat, or whether adipose stores can be mobilized, and how quickly, is also not known.

Typical of many refueling studies, one study showed that increasing calories from 57% carbohydrate to 68% or 88% carbohydrate results in more muscle glycogen after repeated bouts of exercise, in proportion to the amount of carbohydrate ingested.

Although both the 68% and 88% carbohydrate diets increased intramuscular glycogen, the 88% carbohydrate diet led to decreased muscle triglyceride concentrations.³

Even Better: Don't Get Behind

If you ride a bicycle for 6 hours, why wait to reload when you get home?

Why not stop after a few hours and have a good snack or lunch?

The more you can keep up, the less you are behind, the less you need to replace when you get home.

Up to about 300 calories per hour may be useful during exercise for today's workout.

If you can eat more while you exercise, even though you may not need calories for today's workout, you may improve your ability to ride with intensity again tomorrow.

Tour de France riders, for example, often consume more than 700 calories per hour while riding.

Summary: Overall Caloric Mix

You need to replace lost carbohydrate and fat stores in muscle.

Adequate carbohydrate and fat calories, rather than percentage guidelines, are what is needed.

At least 200 calories per hour of carbohydrate can be incorporated into muscle glycogen in the first few hours after exercise.

How many calories from fat can be incorporated into muscle per hour is not known. Since there is at least as much intramuscular fat

as intramuscular glycogen, it seems prudent to aim to ingest at least 100 calories of fat per hour for the first few hours after exercise.

There is evidence that post-exercise mood may be better with whole food or mixed-source caloric drinks (carbohydrate, protein, and fat) than with carbohydrate-only fluids.

Although protein has not proved useful in improving glycogen replacement, unless total calories are insufficient, it may be important in rebuilding muscle or for other reasons. Studies are lacking.

My favorite post exercise strategy: Choose "real food," not specialty sports products. Although sports products will be convenient and palatable for some, "real food" is probably better—more complete, balanced, tastier, and less expensive. For example: A quart of fat-free milk, a sandwich, fruit, and a few cookies.

Sodium

Replace sodium lost during exercise, generally with salty foods.

Read more about sodium before events on page 14.

Read more about sodium, including sweat losses during events, starting on page 21.

Read more about sodium, including the sodium content of selected foods, starting on page 162.

Keep Recovery Supplies Handy

It may require planning. Keep a gallon or two of fluids and a cooler in your vehicle if you travel to workouts or events so that you can start the recovery process sooner rather than later.

³ Zderic, T.W., et al. (2000). Effects of 5-day carbohydrate and fat intake on muscle glycogen and triglyceride in cyclists. *Medicine and Science in Sports and Exercise*, 32(5), Supplement abstract 117.

Sweat Mineral Losses

Minerals are lost in sweat. Prolonged exercise, especially in the heat, has the potential to create mineral deficiencies.

Is during-exercise replacement necessary? To answer this question we need to know:

- Is the amount of mineral lost in sweat significant?
- Are daily intakes typically greater than possible sweat losses?
- Are there body reserves or mechanisms to cope with occasional acute deficiencies?
- Will deficiencies result in performance or other problems?

Many minerals have several regulatory mechanisms. For example:

- The kidneys help regulate electrolyte balance. When electrolyte intake is high, excretion through the kidneys allows the body to normalize levels. When electrolyte intake is low, the kidneys conserve. When the kidneys are maximally conserving a mineral, and intake is inadequate, deficiency may result.

The kidneys have the ability to vary the rate of sodium excretion by a factor of more than 100. A normal balance of sodium is maintained through a very wide range of intakes.

- Similar to kidney-regulation, sweat glands may regulate mineral concentration. Concentration may decrease as blood levels fall.
- Storage sites may release minerals when blood levels fall.

Low blood levels of calcium may be corrected by the release of calcium from bone.

Of the 21 minerals possibly important in human nutrition, we will eliminate from discussion the trace minerals arsenic, boron, chromium, cobalt, copper, molybdenum, nickel, selenium, silicon, and vanadium. Too little is known about these minerals. Reliable

data is not available about their concentration in sweat. Functions and toxicities are uncertain.

Details about all 21 minerals and their biochemistries are discussed in detail in the free supplement to this book available at: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

We will eliminate fluorine/fluoride because water is generally fluoridated, and sweat levels are uncertain.

Finally, we will eliminate iodine and chlorine/chloride. These minerals are consumed along with sodium.

This leaves calcium, iron, magnesium, manganese, phosphorus, potassium, and sodium as possible candidates for concern and replacement.

Let us discuss these remaining minerals. Mineral intakes, absorption efficiency, body content, and sweat levels are listed in Table 2.

Intakes are based on US averages. Soil content can considerably change the mineral content of some foods and therefore intake.

Sweat concentrations vary considerably, and reliable data is often not available. Fitter athletes may have different concentrations than those less fit. Concentrations may change as a workout progresses.

Let us look at sodium to see how the table works. (We will discuss details about sodium below.) The typical daily intake is 4,000 milligrams (4 grams). Absorption efficiency is greater than 90%. Therefore, more than 3,600 milligrams are absorbed daily.

The sodium body content of a 70-kilogram (154 pound) person is about 90,000 milligrams (90 grams).

Sweat contains between 230 and 1,700 milligrams of sodium per liter (quart). Assuming an intermediate sweat concentration of 1,000 milligrams, a gallon (4 quarts, 4 liters) of sweat could contain 4,000 milligrams.

Sodium losses in a gallon of sweat can exceed daily intakes and lead to deficiencies.

The Intake X AE / Sweat multiplies typical intakes by absorption efficiency and divides by typical concentrations in one liter (quart) of sweat. This gives an estimate how many liters (quarts) it takes to use up a typical day's intake of the mineral.

Manganese concentrations in sweat are so relatively low that it would take about 300 liters (about 75 gallons) of sweat to use up a typical daily intake.

As you can see from the table, sodium is critical. Just four liters (quarts) of sweat might result in a loss equivalent to a typical daily intake. Calcium and iron are also of concern; as you will read, acute symptoms are not generally a problem.

Mineral	Typical Intake, mg	Absorption Efficiency	Body Content mg/70kg	Sweat mg/L	Intake X AE / Sweat ¹	Sweat Loss Deficiency?
Calcium	500	30%	1,400,000	28	5	Maybe ³
Iron	15	10-35%	4,000	0.1-0.4	15	Maybe ³
Magnesium	300	10-70%	25,000	8.3-14.2	15	No
Manganese	2	5%	20	0.0025-0.0045 ²	33	No
Phosphorus	1,200	55-70%	700,000	40 ⁴	18	No
Potassium	2,700	>90%	250,000	150	16	No
Sodium	4,000	>90%	90,000	230-1,700	4	Yes
Zinc	11	<40-90%	2,000	0.36-0.68 ²	13	No

Table 2. Mineral intakes, body content, and sweat concentrations. Amounts are given in milligrams for easy comparison. ¹Intake X AE / Sweat = typical daily intake, multiplied by typical absorption efficiency, divided by amount in 1 liter (quart) of sweat. ²Biolab Medical Unit (UK) reference ranges. Maybe³ means that deficiencies are common in the general population, and that sweat losses could worsen such deficiencies. ⁴Estimate.

Calcium

With an intake of 500 milligrams and an absorption efficiency of about 30%, about 150 milligrams of calcium are absorbed daily.

With a loss of about 28 milligrams per liter of sweat, it is easy to sweat out about 112 milligrams of calcium with a gallon (4 quarts, 4 liters) of sweat. This could impact your daily intake.

Acute exercise symptoms are generally not a problem. Calcium deficiency symptoms occur over time, generally resulting in osteoporosis and its symptoms.

Calcium deficiency is relatively common in the general population and aerobic endurance athletes can increase their losses with sweating. In addition to targeting calcium intake through diet, it is reasonable for some athletes to assure intake of the RDA with a daily supplement.

Read more about calcium nutrition on in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Iron

With an intake of 15 milligrams and an absorption efficiency of about 25%, about 4 milligrams of iron are absorbed daily.

With a loss of about 0.3 milligrams per liter of sweat, it is easy to sweat out about 1.2 milligrams with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

As one becomes iron-deficient, absorption increases, so theoretically a new iron balance might be achieved.

Acute exercise symptoms are not a problem. Iron deficiency occurs over time, generally resulting in anemia and its symptoms.

Iron deficiency is relatively common in the general population, particularly in women, and aerobic endurance athletes can increase their losses with sweating. In addition to targeting iron intake

through diet, it is reasonable for some athletes to assure intake of the RDA with a daily multivitamin/multimineral supplement.

Keep in mind that iron excess can be a serious problem.

Read more about iron nutrition in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Magnesium

With an intake of 300 milligrams and an absorption efficiency of about 50%, about 150 milligrams of magnesium are absorbed daily.

With a loss of about 10 milligrams per liter of sweat, it is easy to sweat out about 40 milligrams of magnesium with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

Although magnesium deficiency could theoretically result from exercise, no studies have shown improved performance with supplements and diarrhea is a frequent side effect.

In addition to targeting magnesium intake through diet, it is reasonable for some athletes to assure intake of the RDA with a daily multivitamin/multimineral supplement.

Read more about magnesium nutrition in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Manganese

With an intake of 2 milligrams and an absorption efficiency of about 5%, about 100 micrograms of manganese are absorbed daily.

With a loss of about 3 micrograms per liter of sweat, it is easy to sweat out about 12 micrograms of manganese with a gallon (4 quarts, 4 liters) of sweat. This will not impact your daily intake.

Read more about manganese nutrition in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Phosphorus

With an intake of 1,200 milligrams and an absorption efficiency of about 60%, about 720 milligrams of phosphorus are absorbed daily.

With a loss of about 40 milligrams per liter of sweat, it is easy to sweat out about 160 milligrams of phosphorus with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

Occasional phosphate supplements may improve athletic performance.

Read more about phosphorus nutrition in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Potassium

With an intake of 2,700 milligrams and an absorption efficiency greater than 90%, about 2,500 milligrams of potassium are absorbed daily.

With a loss of about 150 milligrams per liter of sweat, it is easy to sweat out about 600 milligrams of potassium with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

Although potassium can occasionally be a problem to replace for athletes in ultra-distance events who rely solely on potassium-poor fluids for nutrition, those who eat solid food are usually protected against deficiency.

Read more about potassium nutrition in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Sodium

Sodium is the electrolyte priority for the aerobic endurance athlete. A low concentration of sodium in the blood is associated with weakness, fatigue, seizures, and occasionally death.

For the non-athlete, the daily requirement is about 500 milligrams.

The average American ingests two to five grams (2,000 to 5,000 milligrams) of sodium a day. Typical intakes may vary considerably. Many individuals consume half this amount and many consume more than twice this amount.

With an intake of 4,000 milligrams and an absorption efficiency over 90%, about 3,600 milligrams of sodium are absorbed daily.

With a loss of about 1,000 milligrams per liter of sweat, it is easy to sweat out about 4,000 milligrams of sodium with a gallon (4 quarts, 4 liters) of sweat. This could overwhelm your daily intake.

Blood sodium levels may drop.

In temperate weather conditions, this may take 4 or 5 hours. In high-heat conditions, sodium depletion can occur in just a couple of hours.

In many athletes, low sodium problems first occur in target long-distance events—because these events may last 50% longer than the longest previous training session.

Many athletes who are sodium-depleted are also dehydrated. However, those with low blood sodium are often relatively less dehydrated than their competitors who have blood levels closer to normal.

The reason is that athletes tend to rehydrate with fluids that have a lower sodium concentration than blood. Those who drink the most tend to dilute sodium the most and have lower blood concentrations.

For aerobic-endurance athletes, it is reasonable to plan on an intake of up to a maximum of one gram (1,000 milligrams) of sodium per liter of fluid loss. This is about one-half teaspoon of salt.

Cyclists may have a relatively easy time ingesting sodium snacks. Triathletes can ingest salt snacks while cycling. Runners tend to have finished their event before trouble with sodium sets in. Walkers, in the heat for many hours, are the most at risk, especially if they rely only on gels and water for their event nutrition.

Here is another reason for consuming salt: It helps the body rehydrate.

Read more about sodium before events on page 14.

Read more about sodium after events on page 20.

Read more about sodium, including the sodium content of selected foods and hyponatremia starting on page 162.

Zinc

With an intake of 11 milligrams and an absorption efficiency of about 60%, about 7 milligrams of zinc are absorbed daily.

With a loss of about 0.5 milligrams per liter of sweat, it is easy to sweat out about 2 milligrams of zinc with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

In addition to targeting zinc intake through diet, it is reasonable for some athletes to assure intake of the RDA with a daily multivitamin/multimineral supplement.

Read more about zinc nutrition in the free supplement to this book available through at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Muscle Cramps

Many of the reasons for muscle cramps are still unknown.

Fluid and mineral imbalance may be one of many causes. This imbalance is probably more of a problem in the local muscle cell area than a reflection of overall body electrolyte imbalance or dehydration. Some of the electrolytes implicated are sodium, magnesium, potassium and calcium.

Target this cause of muscle cramps by eating a diet rich in carbohydrate, magnesium, potassium, and calcium—a diet good for overall general health as well.

If riding long, hard, or day-after-day in the heat, add sodium to your diet.

Summary

During exercise, it is all about sodium.

Most mineral losses in sweat are unimportant or compensated for by the increased caloric consumption of athletes.

Calcium and iron may be exceptions. Some athletes may need calcium or iron supplements for general health.

A daily multivitamin/multimineral supplement will help provide the RDA of most minerals. Calcium requires a separate supplement.

Free Radicals

Antioxidants

Exercise may increase free radical formation. Antioxidants, which interact with free radicals, are promoted to enhance performance and recovery from exercise.

Free radicals are atoms or groups of atoms with an odd (unpaired) number of electrons.

Free radicals can be formed when oxygen interacts with some molecules. Once formed, free radicals can react with cellular components, such as DNA, or the cell membrane.

Free radicals arise normally during metabolism. Environmental factors such as pollution, radiation, cigarette smoke, and herbicides can also spawn free radicals.

Antioxidants act as scavengers, interacting with free radicals to prevent cell and tissue damage that could lead to cellular damage—thought to be a common pathway for cancer, aging, and a variety of diseases.

Several enzyme systems within the body scavenge free radicals.

The principle antioxidants are vitamin E, beta-carotene, vitamin C, and selenium. Thiamine, riboflavin, pantothenic acid, vitamin D, vitamin K, copper, magnesium, manganese, molybdenum, and zinc also have antioxidant roles. Read more about these individual antioxidants in their respective chapters.

Preventing Cancer and Heart Disease

Studies show lower cancer rates in people whose diets are rich in fruits and vegetables. This has led to the theory that these diets contain substances, possibly antioxidants, which protect against the development of cancer.

Studies have shown that diets with higher intakes of vitamin C are associated with decreased incidence of cancers of the mouth, throat and vocal chords, esophagus, stomach, colon-rectum, and lung. Studies have *not* shown that dietary supplements with antioxidants reduce the risk of developing cancer.

Although antioxidants may have a role in slowing the aging process and preventing heart disease and strokes, good studies do not prove this⁴. Some studies have shown an *increased* risk of heart attack with the use of antioxidants.

It is premature to make recommendations regarding antioxidant supplements and disease prevention.

Exercise and Oxidative Damage

Aerobic exercise can increase oxygen utilization up to 20 times the resting state. This increases the generation of free radicals, prompting concern about enhanced damage to muscles and other tissues.

Do athletes need to defend against increased free radicals resulting from exercise? Can they? Do athletes need to take extra antioxidants?

Regular physical exercise enhances the antioxidant defense system and protects against exercise-induced free radical damage. These changes parallel other adaptations to exercise.

The role of antioxidant supplementation in well-nourished athletes is controversial. Good studies have not proven benefit.

There is no firm evidence to support supplementation with antioxidants.

Performance

Antioxidant supplements have not been shown to be useful as performance enhancers.

Toxicity

Antioxidants supplements are not harmless. They have interactions and potential toxicity.

Little is known about the long-term consequences of megadoses of antioxidants.

Bottom Line: Fruits and Vegetables

Other chemicals and substances found in natural sources of antioxidants may also be responsible for the beneficial effects.

The best way to ensure an intake of the antioxidant nutrients is through a balanced diet including five or more daily servings of fruits and vegetables.

⁴ For a discussion about what makes a good study, see page 135.

Hydration

Hydration Key Points

- Adequate hydration is crucial to athletic performance.
- Keep fluids handy.
- Begin training or events hydrated.
- The longer the event, the more important it is to keep up with fluid losses.
- For single-day events:
 - Aim to drink 16 ounces (2 cups, 500 milliliters, 1 standard waterbottle) per hour while exercising moderately or in temperate conditions.
 - Aim to drink up to 32 ounces (1 quart, 1 liter) per hour when exercising at high intensity or in the heat.
- For multiple-day events:
 - Replace fluids lost, up to 48 ounces (1.5 quarts, 1.5 liters) per hour when exercising in the heat.
 - Reduce exercise intensity to a level that allows you to replace what you are losing.
- Chilled and flavored fluids improve palatability and promote hydration.
- Carbohydrate concentration to a maximum of 6% (240 calories per quart or liter) may improve the rate of rehydration as well as improve performance by providing energy and sparing glycogen.
- Sodium to a maximum concentration of 1,000 milligrams per quart (liter) may improve the rate of rehydration as well as prevent hyponatremia.
- There is no evidence that other minerals in hydration products improve performance.
- There is no evidence that proprietary substances in sports drinks confer any advantages over readily available nutrients.

Requirements: Adequate Intake (AI)

The 2004 US Food and Nutrition Board (FNB) adult daily total water intake AI is 3.7 liters (quarts) for men and 2.7 liters for women.

This includes all water contained in food, beverages, and drinking water.

Aerobic endurance athletes need more.

Why Hydrate?

Dehydration worsens athletic performance.

Replacing liquids that are lost through exercise is one of the easiest and important aids to performance in endurance sports.

Fluids are intracellular—within cells, and extracellular—for example in blood vessels.

Fluids allow the body's cells to function optimally. Maintaining good hydration is essential to maintaining strength while exercising.

Blood is about 50% fluids. Reduction of blood volume from dehydration affects performance quickly.

Dehydration may reduce not only current performance but also subsequent training effectiveness. It is associated with a decrease in metabolic rate and a shift to carbohydrate energy use at rest—resulting in less carbohydrate available for high-intensity exercise.

A conscious effort to drink may be required—most athletes do not voluntarily drink enough.

It is easy to get dehydrated. Over-hydration is unusual, but occurs—most often in those who exercise at low or moderate intensity for many hours and overdrink, especially with salt-poor solutions.

What Percent Dehydration Affects Performance?

Some studies have shown that as little 2% dehydration (3-pound weight loss for a 150-pound athlete) affects performance.

These studies are often touted by coaches, sport scientists, and companies that market hydration products.

It is not that simple; and not all studies come to this conclusion.

For example, four other studies showed that:

- More than 20% of both boys and girls lost more than 2% of body weight during a triathlon consisting of an 800-meter swim, 30-kilometer bike, and 8-kilometer run. Performance was better in the more dehydrated athletes.
- Neither 2% nor 4% dehydration adversely affected performance.
- A 3.5% reduction in body weight from dehydration was not associated with decreased muscular strength or endurance compared with a 1.3% reduction in body weight.
- One-hour cycle time-trial performance was not improved by hydration during the event.

Bottom Line

In the real world, modest dehydration probably does not affect performance, and for events less than one hour, hydration has not been proven as important as it is for longer events.

Although laboratory performance has been shown to worsen with modest dehydration, in real world competition many 10-K runners and 40-K bicycling time trialists do not drink, even in desert events. During races of less than one hour at maximum effort the disruption of rhythm, the time cost of drinking and the aerodynamic drag of water bottles, may justify not drinking.

The longer the event, the more important it is to pay attention to hydration. Prehydrate and pay attention from the get go—because once behind, it is often difficult to catch up.

Thirst Sensation

Your body responds to dehydration with a sense of thirst. If you are thirsty, dehydration has already happened. The older we get, the slower our body's thirst response becomes.

Recent Studies

Athletes are often unaware of and underestimate their fluid losses and replacement.

In one study, experienced runners lost almost 2-quarts (liters) in a 10-mile run. They estimated their sweat loss to be 1.1 quarts (liters).

In Hawaii Ironman subjects, dehydration was 20 times more common than overhydration.

Estimating Sweat Rate

Athletes can roughly estimate sweat rate by weighing themselves before and after exercise and accounting for urine losses and fluid ingestion.

One quart (liter) of water weighs about 2 pounds.

However, a scale can be misleading.

Glycogen binds, on average, three times its weight in water. Since glycogen depletion is common in events longer than one hour, some weight loss reflects decreased glycogen stores rather than hydration status per se. Glycogen stores normally average about 1 pound (500 grams). If glycogen is completely exhausted, 4 pounds (2 kilograms) of weight loss can be attributed to glycogen exhaustion—1 pound of glycogen and 3 pounds of associated bound water.

Prehydration

If you are training or racing in hot weather, or repeatedly exercising within a short span of time, particular attention must be given to adequate prehydration in the days before racing.

Athletes traveling to races commonly drink less because they neglect to fill or bring waterbottles and are trapped in car or airplane seats.

You want not only your blood vessels to be hydrated, but your cells to be filled as well. Consciously drink plenty of fluids and look for clear urine for several days before racing.

Look for Clear Urine

You generally know that your *blood* is well-hydrated when your urine is clear. Two caveats: B vitamins may color the urine, and, conversely, clear urine does not guarantee that you are well-hydrated.

Recent Studies

Urine color was found to be reliably correlated with percent dehydration during a 30-mile mountain bike race that followed a pre-exercise hyperhydration protocol.

Does concentrated urine mean that one is not well-hydrated? That is the common view. In fact, NCAA wrestlers cannot have their body composition measured for the wrestling season if specific gravity is >1.020 . However, a study following well-hydrated volunteers found urine specific gravity was often more concentrated than that level.

Cell Dehydration

Lost blood fluid volume is quickly replaced by drinking water. Cell dehydration, however, is different.

The cells of your body are mostly water. Fluid loss from the cells may take many hours, or even a day or two, to replace. It is possible to experience cell dehydration, drink a lot, have clear urine, and still be dehydrated in the cells.

When you drink, the fluids travel from your gastrointestinal tract into your bloodstream. The kidneys immediately sense the fullness

of the blood vessels and begin to eliminate what they perceive as surplus fluid. However, your cells may not have had time to absorb fluids and so remain dehydrated.

It is a little like a plant that has not been watered for some time. The soil is dry, and the roots and leaves are dehydrated, so you water it. Before the plant can absorb the water, it has run through the porous, dry soil, leaving the plant leaves still dry.

Keep Fluids Handy

Having fluids readily available encourages drinking.

Hydration backpack systems make sense in some sports. Hydration systems can carry 100 ounces (3 quarts or liters), the equivalent of six standard waterbottles. They can be accessed more easily than waterbottles for some athletes, for example some mountain bikers or unskilled road riders.

Recent Studies

Hydration backpack systems were associated with slightly better hydration and performance than traditional frame-mounted bottles—in a mountain-bike study funded by CamelBak, a backpack hydration system.

Faster/Slower Hydration

Chilled and flavored fluids improve palatability and promote hydration.

Studies have shown that both sodium and carbohydrate improve the rate of absorption of fluids from the gastrointestinal tract and reduce fluid losses in the urine.

Solutions with higher than 6% carbohydrate concentration may delay stomach emptying, slow hydration, and cause gastrointestinal cramping. The hotter or more fatigued the athlete, the less the athlete is able to tolerate concentrated fluids.

Recent Studies

Most commercial sports drinks contain too little sodium (salt). Higher concentrations of sodium (40+ milliequivalents per liter; or 1,000 milligrams per quart, liter) are more effective for rehydration.

A solution containing sodium 75 milliequivalents per liter (1,875 milligrams per liter or quart) enhances fluid retention more than a solution containing 20 milliequivalents per liter (500 milligrams per liter or quart).

Bottom Line

The mouth and the gut are different. Although the gut absorbs sodium-rich fluids better, many athletes cannot get them past the mouth because the mix tastes revolting. Salty snacks may be a better way to replace your sodium.

How Much Water Can You Lose?

Sweat rates have been reported higher than 3.5 quarts (liters) per hour with heavy exertion in the heat.

More typically, athletes sweat about 16 ounces (½ quart, 500 milliliters, 1 standard water bottle) per hour when exercising moderately in cool or temperate conditions.

Athletes sweat about 32 ounces (1 quart, 1 liter, 2 standard waterbottles) per hour when exercising moderately in hot conditions.

I sometimes ride from Del Mar to San Clemente, California, and back—about 85 miles. On the way, I drink from my two large water bottles. In San Clemente, I buy two or three bottles of fluid. I drink one there and use the rest to refill my water bottles. On the average, I leave at 147 pounds and come back at about 142 pounds. If I am 5 pounds lighter at the end of the ride, it means I am still down more than 2 quarts of fluid.

Once I rode a 40-K time trial in 90°+ heat and high humidity. I drank 2 gallons within an hour of the end of the ride—and I still was not tanked up.

Once I went on a desert trip with my wife and rode a century. Both of us needed to replace almost one-third of our weight in fluids that day. I drank 45 pounds—almost 5 gallons. That is 20 quarts. That is eighty 8-ounce glasses of fluid!

It is easy for the body to use a lot of fluid quickly.

How Much Should You Drink?

It is generally recommended that athletes consume enough fluids to replace sweat and urine losses during training and events.

Few athletes do.

Since not all that is drunk is retained (about 60% is eliminated by the kidneys as urine), some advocate rehydrating with 150% of lost fluids. Studies show that 50% to 100% more fluid is required, depending upon simultaneous sodium ingestion.

Single-Day Training/Events

Aim to drink 16 ounces (500 milliliters, 1 standard waterbottle) per hour while exercising moderately or in temperate conditions.

Aim to drink up to 32 ounces (1 quart, 1 liter, 2 standard waterbottles) per hour when exercising at high intensity or in the heat.

Most athletes cannot drink more than 32 ounces per hour and so get dehydrated during training or events in the heat. For many events, modest dehydration is not a problem.

Ultraendurance and Multiple-Day Training/Events

For ultraendurance events that last more than a single day, or athletes repeatedly competing over several days, athletes cannot afford to get behind. They must keep up with fluid losses.

Athletes can learn to tolerate up to 48 ounces per hour.

Replace fluids lost, up to 48 ounces (1.5 quarts, 1.5 liters, 3 standard waterbottles) per hour when exercising in the heat.

If you cannot keep up with losses, pace: Reduce exercise intensity to a level that allows you to replace what you are losing.

Recent Studies

Weight loss during exercise is directly related to fluid losses during exercise.

Predicting fluid loss before exercising based on initial body weight, exercise type, exercise intensity, ambient temperature, and percent relative humidity accounted for only about half of the variability of observed loss in recreational exercisers.

Cycling in a hot environment for an hour? Drinking 1,000 milliliters of cool water immediately before cycling or splitting the fluids into four 250 milliliter doses at 0, 15, 30, and 45 minutes during the hour results in no significant thermoregulatory or performance differences.

Electrolyte Additives

What is lost with sweating and hard breathing (the lungs moisturize air) is mostly plain water. Some electrolytes or salts (sodium, potassium, chloride, etc.) are lost, but it is mostly water. Water is the most important item to replace.

Expensive athletic drinks or solutions are not necessary for usual athletic activity.

Electrolytes may help the body absorb and retain water.

Aerobic endurance athletes who exercise daily for more than a couple of hours can deplete the body's reserves of some electrolytes, principally sodium and chloride.

Sodium and chloride may come from salty snacks, supplements, or be present in fluids consumed.

For a more complete discussion, read *Sweat Mineral Losses* on page 21.

Hyponatremia

Rehydrating without adequate sodium can result in low blood sodium or hyponatremia, potentially life-threatening. Read more about sodium and hyponatremia on pages 24 and 166.

Calorie Additives

Calories in solution help water and electrolytes move from the gut into the bloodstream.

For exercise more than 1 hour in duration, studies have shown that solutions containing carbohydrate allow for improved performance compared with plain water.

A few studies have shown that calories can help performance even during shorter events.

Sports drinks, soft drinks, and fruit juices provide the calories as well as replace some of the modest electrolyte losses that occur with sweating. Note that fruit juices must usually be diluted to be tolerated while exercising, and that even so, some individuals do not tolerate fruit sugar (fructose) as well as other sugars.

Even if you are only going to exercise a short time, it makes sense to always have some calories in what you drink. They may not be necessary for performance today, but who knows—maybe you will end up exercising longer than you were planning, or perhaps it will help you keep your glycogen topped up and allow you to perform better tomorrow. Those who train daily or exercise more than 10 hours per week are always fighting glycogen depletion.

Read more about carbohydrate solutions under *Maltodextrin Nutrition* on page 51 and *Nutrition While Exercising* on page 15.

Sports Drinks

Sports drinks can be helpful. Before- and during-exercise sports drinks generally do not contain protein or fat. These ingredients are sometimes included in recovery drinks.

Some riders cannot tolerate the fruit sugar (fructose) in fruit juices, whereas other simple carbohydrates, including glucose, may not present a problem.

As described earlier, because the intestines often react to the number of sugar particles in solution, stringing together single-molecule sugars into chains of glucose polymers or maltodextrins may allow more calories to be consumed without increasing gastrointestinal upset. For more information about maltodextrins, see page 51.

There is hardly any evidence, though much hype and promotion, that adding a small amount of protein to drinks may improve recovery.

For more information about sports drinks, see page 97.

For a discussion about protein and recovery drinks, see page 66.

Make Your Own Sports Drink

For a standard 16-ounce waterbottle, mix:

- 16 ounces water
- ½ cup maltodextrin
- 1 to 2 tablespoons of concentrated lemonade or fruit juice
- 1/16 teaspoon salt

Each 16-ounce bottle will contain about 200 calories and 100 mg of sodium. This may not provide enough sodium when many waterbottles are required during the course of training or an event; even so, this may taste too salty for some athletes. If so, rely on salty snacks for your sodium.

Recent Studies

Proprietary sports drink ingredients have not been shown to offer any advantage over standard ingredients when independently studied.

The manufacturer of Revenge claims it may improve performance by decreasing blood viscosity. Not so in a study that examined ingestion of 20 ounces of the product.

For more on marketing hype of sports nutritionals, see *Ergogenic Products* on page 111 and *Nutritional Promotion & Quackery* on page 132.

Oxygenated Water

Although one study showed that oxygenated water benefited highly-trained cyclists, almost all studies show no benefit.

Whether there can possibly be any help from this product is doubtful. Look at it this way:

- One quart (liter) of tap water contains about eight milligrams of dissolved oxygen.
- One company claims its product contains four times that—32 milligrams.
- A 154-pound (70 kilogram) recreational athlete with a VO₂ max of 50 milliliters/kilogram/minute will use about 100 milligrams of oxygen every second.
- To get a one percent boost, athletes must chug 2.5 quarts (liters) of oxygenated water every minute for each minute of exercise.
- The technical term for this is drowning.

Glycerol

Glycerol, a three-carbon molecule, forms the backbone of triglycerides. It may also act to increase hydration, but so does a little extra salt in the diet.

Studies examining the effectiveness of glycerol have had mixed results, mostly negative. Cramping and weight gain are side effects.

Adding common salt to the diet 24 to 48 hours before prolonged exercise in the heat may be as, if not more, valuable.

Real Juice

We were back at my car after a 60-mile ride. I had a gallon thermos of drink in the trunk. A previous Olympian was with me. He was thirsty. I gave him some purplish fluid.

“What’s that?” he said, swallowing eagerly. “That’s great. Is it Cytomax, or a new energy drink?”

“Not too strong?” I asked.

“No. Terrific. Is this why you go so fast?”

“Don’t know, but it helps,” I said.

“What is it? Who makes it?” he asked again.

“It’s from the grocery store,” I said. “Tropical Fruit, made by Dole. 100% pure juice, diluted about 50/50 with water.”

“Wow!” he said. “Real juice!”

Caffeine Additives

To get you going or keep you going, caffeine in solution (for example, coffee, tea, Coke, or Pepsi) can be useful.

For a discussion about the ergogenic (performance-enhancing) and ergolytic (performance-robbing) effects of caffeine, see pages 114 and 125.

Alcohol

Alcohol is ergolytic—performance-robbing.

Like caffeine, it is a diuretic robbing you of fluid. It slows you down. It makes your legs heavier. Physical activity increases the intoxicating effect of alcohol. With your judgment impaired, skills worsen. On a bicycle, you can easily crash.

For more information about alcohol, see page 93.

Make It Taste Good

Plain warm water does not taste great. Chilled fluids go down more easily. A little flavor, a little sugar, a little electrolyte makes it taste better. Do not overdo it: too sweet or too salty tastes bad. Having good-tasting fluids allows you to drink more.

Palatability changes depending upon hydration status and exertion level. (What tastes good at rest does not taste the same when tired, hot, sweaty, and exercising.)

Summary

Review the key points at the beginning.

Hydration improves performance. Although some level of dehydration may be tolerated without adversely affecting performance, the longer the event the more important it is to pay attention to hydration and have a hydration strategy.

Carbohydrate, sodium, flavor, cooling of fluids, and accessibility can help improve hydration.

Part 2:

Calories

Calories Introduction

Calories provide the energy that the body needs to operate.

The major nutrient divisions of carbohydrate, protein, and fat can all be used by the body to provide energy. (Alcohol also provides calories.)

The traditional high-performance aerobic-endurance diet consists of 60% to 70% of calories as carbohydrate, 10% to 15% as protein and 15% to 25% as fat. Read more about macronutrient mix starting on page 47.

Protein and carbohydrate supply 4 calories of energy for each gram. Fat supplies 9 calories for each gram. Alcohol supplies 7 calories per gram.

A pound of carbohydrate or a pound of protein provides less than one-half the calories of a pound of fat. Carbohydrate and protein have less than one-half the caloric density of fat.

Caloric foods not promptly used for immediate energy are converted to glycogen or stored as fats. Normally, up to 2,000 calories are stored as glycogen (about one pound's worth). Normally, in excess of 50,000 calories are stored as fat (in excess of 14 pounds worth).

The major nutritional health problem in the US today is *overnutrition*. Excess calories in the diet may lead to weight gain, which is detrimental to health and performance. Read about body fat, obesity, and tips to lose weight in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Although obesity is a serious problem, so is undernutrition.

Many athletes whose performance depends on low body weight are subject to decreased performance or illness because they are too thin. This is discussed further in *Too Thin?* in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Daily Caloric Needs

You need energy for basal metabolism, the basics of running your body. Basal metabolism includes pumping your heart, circulating blood through your kidneys, liver, and other organs, supplying your brain with energy, fueling the rods and cones of your eyes to see, manufacturing salivary and gastrointestinal juices for digestion, and moving food through your bowels.

Beyond basal metabolism, you need energy to fuel your daily activities, including exercise.

Basal Metabolism

Many well-known formulae exist for estimating basal metabolism energy needs.

Methods that are more accurate are used in laboratories or intensive care units.

Many free calculators are also available on the internet. Use a search engine with the keywords: basal, metabolism, calculator.

Following are three of the most well-known formulae. If you check your own figures, you may find that figures vary, sometimes significantly:

Simplest

Estimate based on weight:

30 calories per kilogram or 13.5 calories per pound.

Harris-Benedict Equations

Estimate based on gender, height, age, and weight:

Male: $66 + (13.7 \times \text{wt in kg}) + (5 \times \text{ht in cm}) - (6.8 \times \text{age in years})$

Female: $665 + (9.6 \times \text{wt in kg}) + (1.85 \times \text{ht in cm}) - (4.7 \times \text{age in years})$

Schofield Equations

Estimate based on gender, age, and weight in kilograms:

Male:	Age 18-30:	$Wt \times 15.1 + 693$
	Age 30-60:	$Wt \times 11.5 + 1113$
Female:	Age 18-30:	$Wt \times 14.8 + 487$
	Age 30-60:	$Wt \times 8.1 + 846$

Activity Energy Needs

Tables and formulae about the energy needs of various exercise activities are approximate.

For example, the energy needed to ride a bicycle may be given for 15 miles per hour. Are you riding a road bicycle or a mountain bicycle with wider, more road-resistant tires? Are you in an aerodynamic position, or sitting upright on a bicycle with grocery-store basket? Is there a headwind? Are you riding on level ground, climbing, or descending? Are you riding alone or in the slipstream of others?

Based on Distance

One can only very roughly estimate the calories burned based on distance.

Cycling

1. For moderate road riding, you burn roughly 25 calories for every mile you ride, and 25 calories for every 100 feet you climb.

Double the burn rate for single-track mountain biking.

Burn rate is lower per mile at slower speeds and higher per mile at faster speeds.

Drafting reduces burn rate; upright bicycle position increases burn rate.

Heavier riders burn more than lighter riders do.

2. Another method: calories used per hour = $(0.046 \times V \times W) + (0.066 \times V^3)$, where V = velocity in miles per hour, and W = weight of rider and bike in pounds.

By this formula, a 110-pound cyclist, riding a 20-pound bike, and traveling at 12 miles per hour, would use about 186 calories per hour. A 150-pound cyclist, riding a 20-pound bike, and, and traveling at 12 miles per hour, would use about 208 calories per hour. Time trialing at 25 mph, a 150-pound cyclist would use about 1,200 calories per hour.

Running and Walking

Estimate calories burned as 1.1 calories per kilogram per kilometer, or 0.8 calories per pound per mile. (These two estimates are close, less than one percent different.)

Weigh 60 kilograms (132 pounds)? Figure you burn about 660 calories running a 10K (6.2 miles), or about 2,770 calories running a standard 42-kilometer (26.2-mile) marathon.

Based on Perceived Exertion or Heart Rate

One can very roughly estimate caloric burn rates from exercise intensity.

Assuming you weigh 60 kilograms or 132 pounds, are a moderately-fit recreational rider, and are riding a road bicycle on level ground, you burn about 250 calories an hour riding easy (10 miles per hour, 60% of maximum heart rate), 500 calories per hour riding moderately (18 miles per hour, 75% of maximum heart rate), and 750 calories an hour riding hard (23 miles per hour, 90% of maximum heart rate).

For fitter riders, at a given speed, the burn rate will be similar but the percent of maximum heart rate will be lower.

Heavier riders use more energy per mile than lighter riders do.

Some heart rate monitors estimate calories burned. They provide rougher estimates than those based on power, described below.

Based on Power

The amount of calories you burn closely parallels the amount of work you perform.

One can accurately estimate caloric use with power meters.

Many power meter bicycle computers give a caloric figure.

These figures are more accurate than those estimated with heart rate monitors that do not measure power.

A joule is one watt of power for one second. There are 3,600 seconds in an hour. One kilojoule equals 1,000 joules. Therefore, averaging 100 watts of power for one hour yields 360 kilojoules of work.

Since a kilojoule equals 0.24 calories,⁵ and since the body is about 24% efficient in converting energy to muscular work, kilojoules of work provide a good estimate of calories burned.

That is to say if your total ride work is 1,200 kilojoules, you have also burned about 1,200 calories in producing that work.

In calories, you burn roughly 3.6 times the average watts you maintain over an hour.

Summary

As an aerobic endurance athlete, you may need many more calories than a sedentary person. You can estimate exercise energy requirements. Without a power meter, many estimates may be very rough.

⁵Technically one kilojoule equals 0.24 *kilocalories*. A scientific kilocalorie is popularly referred to as a calorie.

Digestion⁶

Gastrointestinal Tract

The digestive system is a series of hollow organs joined in a long, twisting tube from the mouth to the anus (see Figure 1).

Inside this tube is a lining called the mucosa. In the mouth, stomach, and small intestine, the mucosa contains tiny glands that produce juices to help digest food.

The salivary glands, the liver, and the pancreas produce digestive juices that reach the mouth and intestine through small tubes. In addition, parts of other organ systems (for instance, nerves and blood) play a major role in the digestive system.

Why is Digestion Important?

When we eat foods such as bread, meat, and vegetables, they are not in a form that the body can use as nourishment. Our food and drink must be changed into smaller molecules of nutrients before they can be absorbed into the blood and carried to cells throughout the body.

Digestion is the process by which food and drink are broken down so that the body can use them to build and nourish cells and to provide energy.

How is Food Digested?

Digestion involves the mixing of food, its movement through the gastrointestinal tract, and the chemical breakdown of the large molecules of food into smaller molecules. Digestion begins in the mouth, when we chew and swallow, and is completed in the small intestine. The chemical process varies for different kinds of food.

⁶ Adapted from non copyrighted material of The National Digestive Diseases Information Clearinghouse (NDDIC). <http://digestive.niddk.nih.gov/ddiseases/pubs/yrdd>. Accessed 11-15-2004.

Movement of Food

The large, hollow organs of the digestive system contain muscle that enables their walls to move. The movement of these organ walls propels food and liquid and mixes the contents within each organ.

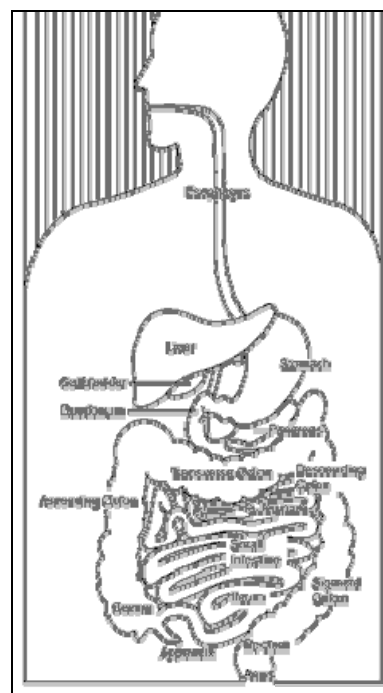


Figure 1. The digestive system.

Typical movement of the esophagus, stomach, and intestine is called peristalsis. The action of peristalsis looks like an ocean wave moving through the muscle.

The muscle of each organ produces a narrowing in one area and then sequentially narrow portions slowly down the length of the organ. These waves of narrowing push the food and fluid in front of them through each organ.

The first major muscle movement occurs when food or liquid is swallowed. We are able to start swallowing by choice. Once the swallow begins, it becomes involuntary.

Swallowed food is first pushed into the esophagus. It connects the throat above with the stomach below. At the junction of the esophagus and stomach, there is a ring-like valve closing the passage between the two organs. As the food approaches the closed ring, the surrounding muscles relax and allow the food to pass.

Food then enters the stomach, which has three mechanical functions.

1. Store the swallowed food and liquid. This requires the muscle of the upper part of the stomach to relax and accept large volumes of swallowed material.
2. Mix up the food, liquid, saliva, and digestive juice produced by the stomach. The lower part of the stomach mixes these materials by its muscle action.
3. Empty its contents bit by bit into the small intestine.

Several factors affect emptying of the stomach, including the nature of the food (mainly its fat and protein content) and the degree of muscle action of the emptying stomach and the next organ to receive the contents (the small intestine).

As the food is digested in the small intestine and dissolved into the juices from the pancreas, liver, and intestine, the contents of the intestine are mixed and pushed forward to allow further digestion.

Finally, all of the digested nutrients are absorbed through the intestinal walls.

The waste products of this process include undigested parts of the food (fiber), and older cells that have been shed from the mucosa. These materials are propelled into the colon, where they remain, usually for a day or two, until the feces are expelled by a bowel movement.

Digestive Juices

The glands that act first are in the mouth—the salivary glands. Saliva produced by these glands contains the enzyme amylase that begins to digest the starch from food into smaller molecules.

The next set of digestive glands is in the stomach lining. They produce stomach acid and the enzyme pepsin that digests protein.

After the stomach empties the food and juice mixture into the small intestine, the juices of two other digestive organs mix with the food to continue the process of digestion.

The first of these organs is the pancreas. It produces a juice that contains a wide array of enzymes. These enzymes include pancreatic amylase, pancreatic lipase, trypsin, and nucleases that respectively break down the carbohydrate, fat, protein, and nucleic acids in food.

Other enzymes that are active in the process come from glands in the wall of the intestine.

The liver produces yet another digestive juice—bile. Bile contains acidic bile salts, not enzymes. The bile is stored between meals in the gallbladder. At mealtime, it is squeezed out of the gallbladder into the bile ducts to reach the intestine and mix with the fat in our food. The acidic bile salts dissolve the fat into the watery contents of the small intestine, much like detergents that dissolve grease from a frying pan. After the fat is dissolved, it is digested by enzymes from the pancreas and the lining of the intestine.

Absorption and Transport of Nutrients

Digested molecules of food, as well as water and minerals from the diet, are mostly absorbed from the cavity of the upper small intestine. Most absorbed materials cross the mucosa into the blood and are carried off in the bloodstream to other parts of the body for storage or further chemical change. This process varies with different types of nutrients.

Carbohydrate

The digestible carbohydrates are broken into simpler molecules by enzymes in the saliva, in juice produced by the pancreas, and in the lining of the small intestine.

The three major sources of carbohydrate are starches, sucrose (table sugar), and lactose (milk sugar). Minor sources include glycogen, alcohol, lactic acid, pyruvic acid, pectins, and dextrins. The diet also contains indigestible cellulose fibers.

Starch

Starch is digested in two steps: First, salivary and pancreatic amylase breaks the starch into the disaccharide (two-sugar) molecules called maltose and isomaltose. Second, enzymes in the lining of the small intestine (maltase and isomaltase) split the maltose and isomaltose into glucose molecules that can be absorbed into the blood.

Starch digestion begins in the mouth with salivary amylase. By the time food is swallowed, some of the starch has already been broken down into maltose. Even before starch leaves the stomach to be mixed with pancreatic amylase, more than a third has already been broken down to maltose.

Sucrose

The sucrose of table sugar, another disaccharide, is digested in the lining of the small intestine by the enzyme sucrase into glucose and fructose, each of which can be absorbed from the intestinal cavity into the blood.

Lactose

The lactose of milk, a third type of disaccharide, is changed into absorbable molecules by the enzyme lactase, also found in the intestinal lining.

Into the Blood Stream

The final products of carbohydrate digestion that are absorbed into the blood stream are all monosaccharide (one-sugar) molecules. In the ordinary diet, about 80% are glucose, about 10% fructose, and about 10% galactose.

Fats (Lipids)

The major sources of lipids are triglycerides. Other fats include phospholipids, cholesterol, and cholesterol esters.

A small, clinically unimportant quantity of fat is digested in the stomach by gastric lipase.

The first step in overall digestion of a fat is emulsification—dissolving it into the watery content of the intestinal cavity. The bile acids produced by the liver act as natural detergents to dissolve fat in water and allow pancreatic and enteric lipase enzymes to break the large fat molecules into smaller molecules, fatty acids.

The bile acids combine with the fatty acids and help molecules to move into the cells of the mucosa. In these cells the small molecules are formed back into large molecules, most of which pass into vessels (called lymphatic) near the intestine.

These small vessels carry the reformed fat to the veins of the chest, and the blood carries the fat to storage depots in different parts of the body.

Protein

Giant molecules of protein must be digested by enzymes before they can be used to build and repair body tissues.

Pepsin enzyme in the juice of the stomach starts the digestion of swallowed protein. Further digestion of the protein is completed in the small intestine. Here, several enzymes including trypsin from the pancreatic juice and peptidases from the lining of the intestine carry out the breakdown of protein molecules into smaller molecules, amino acids.

Amino acids are absorbed from the small intestine.

Water, Vitamins, and Minerals

Water, vitamins, and minerals are absorbed in the small intestine and first part of the colon. The second part of the large intestine serves to store material before defecation.

Digestion Control

Hormone Regulators

The digestive system contains its own regulators. The major hormones that control the functions of the digestive system are produced and released by cells in the mucosa of the stomach and small intestine.

Digestion

The hormones that control digestion are gastrin, secretin, and cholecystokinin (CCK):

- *Gastrin* causes the stomach to produce an acid for dissolving and digesting some foods. It is also necessary for the normal growth of the lining of the stomach, small intestine, and colon.
- *Secretin* causes the pancreas to send out a digestive juice that is rich in bicarbonate. It stimulates the stomach to produce pepsin, an enzyme that digests protein. It also stimulates the liver to produce bile.
- *CCK* causes the pancreas to grow and to produce the enzymes of pancreatic juice, and it causes the gallbladder to empty.

Appetite

Additional hormones in the digestive system regulate appetite:

- *Ghrelin* is produced in the stomach and upper intestine in the absence of food in the digestive system and stimulates appetite.
- *Peptide YY* is produced in the gastrointestinal tract in response to a meal in the system and inhibits appetite.

Both of these hormones work on the brain to help regulate the intake of food for energy.

Nerve Regulators

Two types of nerves help to control the action of the digestive system, extrinsic and intrinsic nerves.

Extrinsic

Extrinsic (outside) nerves come to the digestive organs from the unconscious part of the brain or from the spinal cord. They release a chemical called acetylcholine and another called adrenaline.

Acetylcholine causes the muscle of the digestive organs to squeeze with more force and increase the “push” of food and juice through the digestive tract. Acetylcholine also causes the stomach and pancreas to produce more digestive juice.

Adrenaline relaxes the muscle of the stomach and intestine and decreases the flow of blood to these organs.

Intrinsic

Intrinsic (inside) nerves make up a dense network embedded in the walls of the esophagus, stomach, small intestine, and colon.

The intrinsic nerves are triggered to act when the walls of the hollow organs are stretched by food. They release many different substances that speed up or delay the movement of food and the production of juices by the digestive organs.

Athlete Considerations

Bonking, Glucose Fast

Bonking is caused by low blood sugar. Bonking often responds within a few minutes to carbohydrate ingestion. Why so quick a response? Like a diabetic with a hypoglycemic reaction that quickly responds to glucose, remember that carbohydrate digestion begins

within seconds in the mouth, and that glucose gets into the blood stream quickly.

Fructose Slower

Not all sugars travel as quickly into the blood stream. Glucose makes its way into the bloodstream five times as fast as fructose.

Some studies indicate that glucose can provide energy more quickly to exercising athletes, but that fructose can provide more sustained energy.

More athletes report difficulty digesting fructose during exercise than glucose or sucrose.

Fats Slowest

Fat, and to a lesser extent protein, slows digestion when compared with carbohydrate.

This can be an advantage. Fats may result in a slow release of calories into the blood stream. The night before an event, a meal with carbohydrate, fat, and protein will take longer to digest than one of carbohydrate alone. Some studies indicate that morning liver glycogen levels may be higher with this strategy.

This can be a disadvantage. A fatty meal before competition slows digestion and is more likely to result in cramping and indigestion than one emphasizing carbohydrate.

Solids and Hard Work

As we have seen, the digestive tract uses muscles to propel food. As all muscles, digestive muscles need blood to work.

If you are working hard, your leg muscles need your blood. If it is hot, lots of blood goes to skin to help cooling. If you are dehydrated, you have less blood volume.

These competing demands mean that during exercise there may be little blood available to keep intestinal muscles working. The gastrointestinal tract may shut down. You may get abdominal

cramps. If you eat or drink, the food or fluids may just stay in your stomach, giving you bloating.

Race Nerves

Anxiety causes the nerve regulators of the gastrointestinal tract to shut down the digestive function of the gastrointestinal tract. So pre-race jitters means you may have trouble eating and digesting your food, even if you are sitting down quietly at the table, not exercising.

Energy Sources at Various Exercise Levels

Energy for exercising muscle comes from carbohydrate, fat, and protein.

Carbohydrate may come from blood sugar (from the liver by way of stored glycogen or metabolized amino acids or from the intestine by the absorption of carbohydrate) or from glycogen stores in muscle. Typically, athletes with normal stores have about 2,000 carbohydrate calories stored as glycogen: about 1,500 calories of intramuscular glycogen are stored in muscle cells, and about 500 calories in the liver.

Fat energy may come from the bloodstream by way of adipose tissue or the intestine, or from fat stores in muscle. About 2,500 calories of intramuscular fat (triglyceride) energy are stored in muscle cells. Depending upon percent body fat, about 50,000 calories are stored elsewhere as fat.

Protein supplies the least amount of energy and is usually omitted from consideration. If fat and carbohydrate sources are plentiful, protein supplies about 5% of energy sources. Protein contribution to energy production increases after several hours, when intramuscular carbohydrate and fat stores are depleted. As much as 15% of energy sources may derive from protein if muscle fat and glycogen are depleted.

Figure 2 depicts the contribution of carbohydrate and fat to energy production in a cyclist when energy stores are plentiful. Low activity corresponds approximately to a heart rate of 65% of maximum, moderate activity to a heart rate of 75% of maximum, and high activity to a heart rate of 90% of maximum.

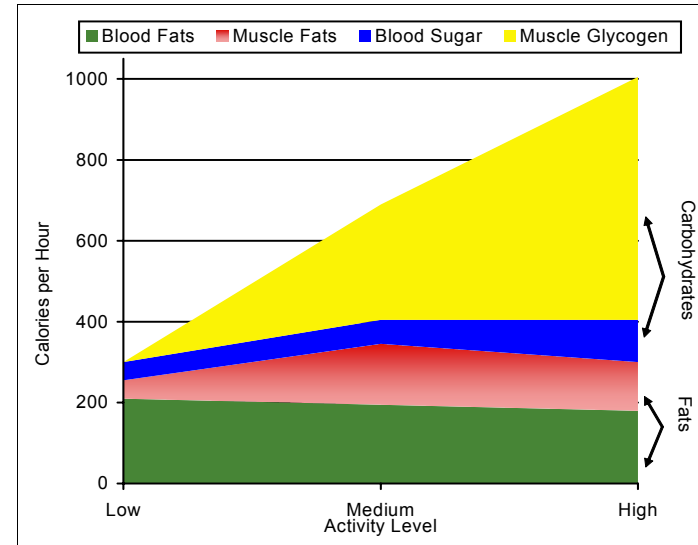


Figure 2. Contribution of energy sources at selected exercise intensities. Adapted from Romijn et al. J Appl Physiol. 1993.

Traditionally the amount of carbohydrate energy used was believed to be higher than in Figure 2. Carbohydrate metabolism was originally calculated based on respiratory exchange ratios—determined from the relative concentrations of carbon dioxide and oxygen expired. Newer techniques have suggested that fat contribution is greater than was previously determined.

The most recent studies show that at low levels of exercise intensity, about 85% of calories are supplied by fats; at medium levels, about half. At high levels of exercise intensity, 70% of energy needs are derived from carbohydrate.

Cyclist and runners use their legs, rather than their arms as do kayakers. At mild-moderate exercise levels, the percentage contribution from carbs and fat is the same whether the legs or the

arms are exercising. At similar higher VO₂ max levels of exercise, arm exercise uses relatively more carbohydrate than leg exercise.

At low levels of exercise intensity, most energy is supplied from fats in the bloodstream. At higher levels of exercise intensity, fat calories come from muscle stores. The absolute energy contribution from fat rises somewhat as exercise progresses from low to medium intensity, but the relative contribution declines. Intramuscular fat (triglyceride) energy at medium-intensity exercise provides less than one-third the energy of muscle glycogen. At high levels of exercise, the absolute amount of fat contribution decreases and the relative amount plummets as glycogen sources predominate.

Blood fat and blood glucose contribute to muscle energy production even at high exercise intensity levels, but the contribution is relatively small compared with that of glycogen. The contribution may increase if glucose is ingested. It is impractical to ingest fat—its utilization takes too long and fat is more likely to slow digestion and cause gastrointestinal upset.

The roughly 50,000 calories of stored fat could fuel the demands of running about 500 miles or bicycling about 2,000 miles. However, stored fat cannot be accessed or processed quickly enough to function as the major energy source of medium- or high-intensity exercise.

A maximum of about 250 calories per hour of ingested carbohydrate may contribute to contemporaneous muscle energy production. Ingesting carbohydrate spares muscle glycogen and allows exercise intensity to increase or remain high longer.

As glycogen stores are used up, exercise intensity cannot be maintained. The relative contributions of fat and protein to energy production rise.

As the physiology adage goes, “Fat burns in the flame of carbohydrate.” When glycogen is exhausted, the rate of fat metabolism also decreases. With glycogen exhaustion, muscle

protein is broken down, metabolized by the liver, and returned to the muscle as blood sugar.

Training may increase the use of muscle fat and the rate of uptake of blood fat for a given exercise intensity, but at high levels of exertion, glycogen remains the fuel of choice. Without glycogen, high-intensity exercise cannot take place.

For those regularly exercising at high intensities, increasing fat in the diet is counterproductive—there is no point in sparing glycogen if the net result is that you have none to spare.

Riding Slowly to Burn Fat—Not!

There is a popular misconception that in order to lose weight, that is fat, one needs to ride slowly, at a low aerobic training pace.

It is true that a greater percentage of the calories burned during exercise at lower intensities comes from fat. However, fat calories are also burned during resting or basal metabolic activities. If your training time is limited, you will lose about as much fat by riding at a higher intensity. Further, high-intensity training stimulates the body to burn more fat after exercise is ended, and it also gets you into better shape.

In order for you to lose weight, your net daily caloric expenditure must exceed your intake. To lose one pound of fat, you have to have a deficit of 3,500 calories. Therefore, in order to lose one pound a week, you have to use 500 more calories daily than you take in.

If your basal metabolic need is 1,000 calories a day, your daily caloric deficit (say, 500 calories)—and weight loss—can be met with basal fat calories just as easily as your exercise calories.

A relevant diet question is this: Do those calories come at the expense of glycogen or fat stores?

If you have relatively unlimited time, a day with a four-hour low-intensity ride will burn the same number of calories as a day

with a two-hour high-intensity ride: 3,000 total calories—2,000 calories for the activity and 1,000 calories for basal metabolism. If you do this every day of the week, and if you ingest just 2,500 calories, the deficit of 500 calories will contribute to an average weight loss of one pound a week. If you have only two hours, you will burn fewer calories with low-intensity work than with high-intensity work. Moreover, with a caloric surplus of 500, you will *gain* an average of a pound a week.

Calories Used	65% Max HR 2 Hours	65% Max HR 4 Hours	85% Max HR 2 Hours
Daily basal: Fat	1,000	1,000	1,000
Exercise	1,000	2,000	2,000
Glycogen	150	300	1,200
Fat	850	1,700	800
Daily total: Fat	1,850	2,700	1,800
Daily total: Glycogen and fat	2,000	3,000	3,000

Table 3. Daily basal and exercise calories used during exercise of selected duration and intensity. Max HR, maximum heart rate.

A 2,500-calorie diet that is 65% carbohydrate will provide 1,625 calories toward glycogen replacement. A 40% carbohydrate diet will provide only 1,000 calories of carbohydrate.

If you eat a high-carbohydrate diet, you will be able to better replace your glycogen, and you will be able to train day after day. If you do not, your glycogen tank will not be filled. After a few days you won't be able to train at as high an intensity level, and you'll run out of high-performance energy—glycogen. You will have to train more slowly and longer to lose as much fat.

The moral is this: if your time is limited, within the limits of your overall training program, ride hard and eat a high-carbohydrate diet.

Carbohydrate Chemistry

Carbohydrates are simple sugars; complex sugars, or starches; and indigestible sugars, or fiber.

Simple Sugars

Simple sugars are categorized as single- or double-molecule sugars.

Single-molecule sugars include glucose, fructose, and galactose.

Double-molecule sugars include sucrose (table sugar—a glucose and a fructose molecule), lactose (milk sugar—a glucose and a galactose molecule), and maltose (malt sugar—two glucose molecules).

Refined sugars are processed sugars devoid of other nutrients.

Natural simple sugars, found in fruits, juices, milk, and vegetables are associated with vitamins and minerals.

Simple sugars are the building blocks of complex sugars, or starches.

Foods and drinks with a lot of simple sugars or simple carbohydrates are often sweet. They include candies, fruit, and nondiet soft drinks. Simple sugars usually come with few vitamins or minerals and are therefore often referred to as “empty calories.”

Complex Sugars—Starches

When simple sugars form long chains of carbohydrate, they are called “complex.” Complex carbohydrates, or starches, are often associated with other nutrients. Foods consisting primarily of complex carbohydrate are pasta, breads, potatoes, and grains. Ingested complex carbohydrate is digested (broken down) into simple sugars before being absorbed into the bloodstream.

The body re-forms a complex carbohydrate for energy storage called glycogen. Glycogen is the critical fuel for performance in the high aerobic and anaerobic threshold range, and is stored primarily within muscle cells and the liver. When one exercises for a couple of hours at high intensity, it is easy to use up these stores.

Since complex carbohydrate is associated with other nutrients and are critical for glycogen replacement, they form the cornerstone of meal planning.

Maltodextrins or *glucose polymers* are medium-length chained carbohydrates, partially broken down from naturally occurring complex carbohydrate. They are often found in energy bars and gels. The contention that they provide a more constant source of energy than simple sugar, one that is easier to digest than naturally occurring complex carbohydrate, is only partially true. The discussion of the glycemic index below, explains why.

Fiber includes indigestible complex carbohydrate. Fiber plays a role in overall health but has little bearing on athletic performance.

Read about fiber beginning in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Glycemic Index

It used to be thought that simple sugars entered the bloodstream rapidly but that their effects on energy production were short-lived. It used to be thought that complex sugars provided a steadier release of food energy.

Studies have shown that the rate of release of sugar into the bloodstream, or glycemic effect, is related to factors other than whether sugars are simple or complex. The rate of digestion of sugars has more to do with cooking, ripening, and the presence of fiber, fats, and proteins associated with the sugar than it does with the presence of simple sugars. For example, a well-baked potato

releases sugar into the bloodstream almost as rapidly as glucose. The release of simple sugars in whole milk is delayed by the presence of fat. Bananas release sugar more rapidly when ripe. Simple sugars consumed as part of a meal raise blood sugar more slowly than when consumed by themselves.

Pure glucose is assigned a glycemic index of 100. The rate of release of sugar into the bloodstream caused by other substances is compared with the release rate of pure glucose.

Sugars that have a glycemic index greater than 80 are considered to be released quickly. Sugars that have a glycemic index between 40 and 80 are considered to be released moderately. Sugars with a glycemic index below 40 are released slowly.

Sugars that release quickly and help to spare or replace burned glycogen may be suitable during or after exercise. Sugars that release moderately slowly may be more suitable several hours before or after exercise.

Food	Index	Food	Index	Food	Index
Glucose	100	Bananas	60	Ice cream	36
Potato, baked	98	Sucrose	60	Milk, whole	34
Carrots, cooked	92	Pasta	50	Milk, fat free	32
Honey	87	Potato chips	50	Beans, kidney	30
Cornflakes	83	Oatmeal	50	Lentils	30
Rice	72	Orange juice	50	Fructose	20
Bread	70	Oranges	43	Carrots, raw	16
Candy bars	65	Beans, baked	40	Beans, soy	15
Raisins	65	Apples	40	Peanuts	10

Table 4. Glycemic index of selected foods.

Why High Carbohydrate?

Macronutrient Mix & Carbohydrate Key Points

- Healthy diets are 60% carbohydrate, 25% to 30% fat, and 10% to 15% protein.
- Carbohydrate is the preferred fuel source for high-intensity exercise.
- Aerobic endurance athletes who exercise more than 10 hours per week benefit from a diet slightly higher in carbohydrate—typically up to 65% carbohydrate, 20% fat, and 15% protein.
- Even higher percentage carbohydrate diets may sometimes be best for aerobic endurance athletes.
- Aerobic endurance athletes may need 7 to 10 grams of carbohydrate per kilogram (3 to 4.5 grams per pound) of body weight per day to replace or top up glycogen stores.

Macronutrient Mix

The traditional high-performance aerobic-endurance diet consists of 60% to 70% of calories as carbohydrate, 10% to 15% as protein and 15% to 25% as fat. Such a diet is typical of Tour-de-France riders. This is referred to as a high-carbohydrate diet.

Low-carbohydrate diets always have their followers. Current examples include the South-Beach, the Atkins, and the 40–30–30 diet, in which carbohydrate makes up only 40% of total calories, and protein and fat make up the divided remainder.

Some have referred to these diets as “high fat.” In terms of percentage fat content, such diets may be typical of the average US diet. However, they have a higher than average protein content.

Where Energy Comes From

Carbohydrate, protein, and fat can all be used to make energy. Approximately 4 calories are produced from each gram of carbohydrate or protein metabolized; about 9 calories are produced from each gram of fat.

Where Energy Goes

The body needs energy to keep the brain working, the heart pumping, the kidneys filtering blood. The amount of energy needed for basal metabolic activities depends on the size of the individual—but let us say the average is about 1,000 calories per day.

The body also needs energy for physical activities—everything from light activity including walking to the heavy activity of high-end endurance exercise. Heavy activity can use several thousand calories a day.

Food energy that the body does not need does not evaporate. The body does not excrete calories. All calories ingested are either used to produce energy or stored as fat. Excess carbohydrate and protein are converted to fat and stored along with the excess dietary fat in the body's fat deposits. (Importantly, the reverse does not happen except to a very minor degree—only a small portion of fat can be converted back to carbohydrate.)

How the Body Makes Energy

The body uses fat, carbohydrate, and protein to make energy via partially different metabolic pathways. Protein is usually used in building muscle or other functions; its contribution to energy production is relatively small and will be ignored in this discussion.

At rest and at low levels of activity, relatively more fat is used for energy production. As activity levels become more intense, more carbohydrate is used to make energy.

Fat requires relatively more oxygen to burn than carbohydrate. Although fat contributes to energy production during exercise, carbohydrate is the key to high efforts. Once your heart rate climbs over 75% of your maximum, more than 50% of your energy is coming from carbohydrate.

This subject is discussed in more depth *Energy Sources at Various Exercise Levels*, on page 43.

Heart Rate % of Max	Carbohydrate Energy %
65	15
75	50
85	60
90	70

Table 5. Percent contribution of carbohydrate to energy metabolism at selected percentages of maximum heart rate.

Glycogen Is Crucial for High-End Energy

When not depleted, the body has about 2,000 carbohydrate calories stored in the form of glycogen. About 500 calories of glycogen are found in the liver and about 1,500 calories are found in muscle.

A one-hour time trial uses up almost all the glycogen stored in muscle. It is easy for a high-performance athlete to burn up almost all stored glycogen with a day's workout. We need glycogen replacement for repeated day-after-day training. Glycogen exhaustion limits or eliminates the role of stored carbohydrate in long-distance endurance activities that take most of a day or longer to complete.

Performance Time Related to Glycogen

There is a direct relationship between the amount of time a fit individual can perform threshold level work and the amount of glycogen present. The more glycogen initially present, the longer an individual can maintain an anaerobic-threshold level of effort.

The graph in Figure 3 demonstrates this linear relationship at 75% of VO₂ max.

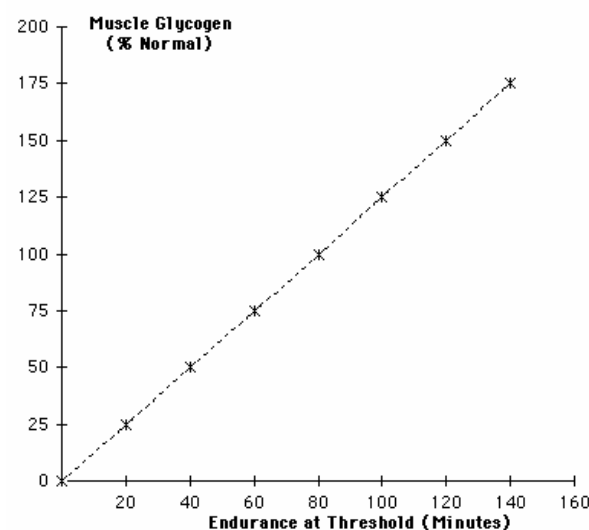


Figure 3. Endurance at threshold is directly correlated with glycogen stores in muscle prior to exercise. Adapted from Bergström et al., Acta Physiol Scand, 1967.

A well-rested, recovered athlete has 100% of normal muscle glycogen. Prior exercise or not replacing carbohydrate results in lower levels. It is possible for muscle to have more than a “normal” amount of glycogen through a process known as glycogen loading, described below.

An athlete with 100% of normal muscle glycogen might be able to exercise at 75% of VO_2 max for 80 minutes. With 75% of normal muscle glycogen, exercise time might be reduced to 60 minutes. With glycogen loading to 125% of normal muscle glycogen, exercise time might increase to 100 minutes.

Glycogen Exhaustion

Repeated bouts of moderate- or high-intensity endurance work can quickly exhaust glycogen reserves.

Figure 4 shows what happens.

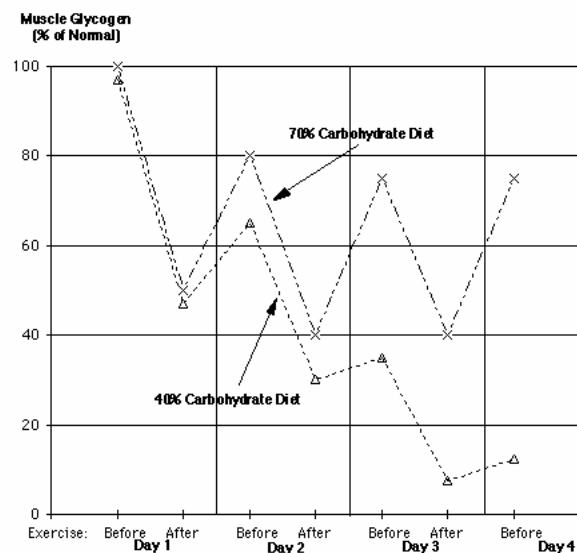


Figure 4. Progressive depletion of glycogen stores after three days of two-hour bouts of heavy endurance training with either 40% or 70% carbohydrate diet. Adapted from Costill & Miller, *Int J Sports Med*, 1980.

A daily program of two hours of activity leads to reduced glycogen levels. Glycogen levels are maintained in proportion to the

amount of carbohydrate ingested. Glycogen exhaustion occurs quickly unless a high-carbohydrate diet is maintained. On the morning after three days of heavy endurance training, an athlete consuming a 70% carbohydrate diet still has about 75% of normal glycogen levels. An athlete consuming a 40% carbohydrate diet has less than 15% of normal levels.

Glycogen Loading

Increased glycogen stores can be created through what is called glycogen loading. This involves a period of (1) glycogen use or exhaustion with heavy exercise, followed by (2) reduced activity accompanied by a high-carbohydrate diet. (Athletes also used to consume a high-fat diet in the first period, but further studies have shown that there is no need to incorporate this strategy to successfully load glycogen.)

A Lot of Carbohydrate Is Needed

Do some very rough arithmetic. A 132-pound (60 kilogram) bicycle racer might use 1,800 calories in basal metabolism and 2,200 in training or racing, for a total of 4,000 calories.

Of those 2,200 calories, 400 might come from fat and 1,800 from glycogen for high-energy use. All that glycogen needs to be replaced in order for the bicycle racer to work as hard the next day.

Carbohydrate calories are needed elsewhere. For example, the brain works only on glucose—it cannot burn fat or protein.

No metabolic processes are 100% efficient.

Let us assume that we need about 2,400 carbohydrate calories to replace the 1,800 lost glycogen calories, to fuel the brain, and to account for inefficiencies.

Therefore, we need 2,400 out of a total 4,000 calories to be carbohydrate, or 60%.

If only 40% of her calories consumed that day come from carbohydrate, full glycogen replacement cannot be achieved.

More Carbohydrate—To a Point

Keep in mind that although carbohydrate has been studied for decades, the role of intramuscular fat is relatively poorly studied. Normally, about 2,500 calories are stored as intramuscular fat.

Typical of many refueling studies, one recent study showed that increasing calories from 57% carbohydrate to 68% or 88% carbohydrate results in more muscle glycogen after repeated bouts of exercise, in proportion to the amount of carbohydrate ingested.

Although both the 68% and 88% carbohydrate diets increased intramuscular glycogen, the 88% carbohydrate diet led to decreased muscle triglyceride concentrations.

Absolute Carbohydrate Calories

It is commonly accepted that most aerobic endurance athletes should consume a diet relatively high in carbohydrate—65% to 70% of total caloric intake.

Many find this approach simplistic, and say it is more important to ingest enough carbohydrate calories to replace those lost through exercise. This often amounts to the same thing, but reflects an approach to the reasoning underlying the simplification. For example, it is not that an athlete consuming 4,000 calories per day needs 65% of calories from carbohydrate; it is that 7-10 grams per kilogram per day—up to 2,400 carbohydrate calories for a 132-pound (60 kilogram) athlete—are needed to replace those lost during exercise.

Studies show that although athletes are able to get the percentage right, based on 7-10 grams per kilogram per day, less than 20% of men and women athletes consumed enough carbohydrate.

What Do Scientific Studies Show?

If you look at scientific research, you have to look at research designed to answer the right questions.

Are you a RAAM rider looking to improve fat metabolism? Are you a weekend warrior? Are you a recreational rider, riding a few times a week at no more than 75% of your maximum heart rate? Are you a frequent high-end training and racing athlete?

The literature supporting high-carbohydrate diets for high-end aerobic endurance athletes is massive, international, and accepted.

The literature supporting higher-fat diets is small. The only study I was able to find concerned athletes who consumed a meal of high (45%) fat vs. low (20%) fat the night before a cycling ergometer test. The riders were rested, were not subject to previous glycogen depletion, and had no breakfast.

40–30–30 proponents often quote this study, saying that it shows the superiority of increasing fat in the athlete's diet. One could just as easily say it supports the notion of eating breakfast!

Diet and Health

The current medical wisdom is that reducing fat in our diets is important for general health. It is believed that fat contributes to heart disease and cancer. Fortunately, the high-carbohydrate diet for athletes achieves these very aims.

Insulin and High-Carbohydrate Diets

Proponents of a higher fat diet (for example, the 40–30–30 diet) point to diabetes and “carbohydrate poisoning.” They claim that high loads of carbohydrate are associated with high insulin levels. They say that insulin contributes to the conversion of carbohydrate to fat, and that increased fat stores contribute to insulin resistance and diabetes. Therefore, so the argument goes, we should reduce our intake of carbohydrate.

I partially agree. However, insulin also increases the formation of glycogen. Moreover, not all carbohydrate causes a rapid rise in insulin levels. The glycemic index—the degree to which foodstuffs increase blood sugar—is variable for different carbohydrates. Complex carbohydrate is the mainstay of the American Diabetes Association’s dietary recommendations.

Moreover, the body’s insulin response to a sugar load during exercise is reduced by the body’s secretion of catecholamines (adrenaline and related compounds). Although carbohydrate consumed before exercise does increase insulin levels, it still results in improved performance.

Pre-, During- and Post-Exercise Feeding

Athletes can divide calorie intake into two areas: calories in and around the training or racing, and all the rest.

For a detailed discussion about pre-, during-, and post-exercise feedings, including pre-event meals, fueling during exercise, and the glycogen window, see *Workout & Exercise Nutrition* starting on page 11.

Bottom Line

Aerobic endurance athletes emphasize carbohydrate in their diets, consuming more than 60% of daily calories from carbohydrate.

Aerobic endurance athletes need 7 to 10 grams of carbohydrate per kilogram (3 to 4.5 grams per pound) of body weight per day to replace or top up glycogen stores.

Maltodextrin Nutrition

The priorities for nutrition for aerobic endurance exercise—long rides, runs, walks, or triathlons—are water, calories, and sodium.

For events under an hour, no special nutrition may be needed. For most events over an hour, concern yourself mainly with fluids and calories. For long-distance events that last most of a day or longer, sodium must also be considered.

Calorie/Energy Loss

It is typical for cyclists to use 2,500 to 3,000 calories during a century. Runners and walkers use 80 to 100 calories per mile.

Some of this energy comes from the body’s stores of carbohydrate (glycogen) and fat. Some energy needs can be met by consuming calories while exercising.

Carbohydrate is the fuel of choice for exercising athletes. Depending upon your size, your body can use up to 300 ingested calories per hour to spare glycogen stores. As a rule, try to consume this many calories for every hour you exercise.

If not racing, cyclists do well to stop periodically and eat “real food”—especially early on in a long ride. Leftover breakfast items such as French toast or pancakes, fig bars, bananas, and Pop-Tarts (perfectly packaged for jersey pockets) are favorites for short stops.

The harder you work, the less you are able to tolerate solid food. Energy bars and gels do work, but after many hours become tiresome for most athletes.

Carbohydrate solutions are a convenient way to get calories. Typical sports drinks and diluted fruit juice have 100–125 calories per 16-ounce bottle. This usually works out to about a 6% sugar solution.

Beverages do not usually have more calories than this because solutions of higher concentration are difficult to digest. More concentrated than 6% solutions are associated with cramps, diarrhea, and other gastrointestinal problems.

There is a trick to increasing caloric content without increasing concentration: maltodextrin nutrition.

Maximizing Calories

You will often want to consume as many calories as you can to gain maximum benefit. However, if you add too many—if the solution you are drinking is a concentrated one—the stomach will empty more slowly, and the gut will send in water from the body to neutralize the concentration of the fluid you have drunk, causing you to temporarily dehydrate yourself further.

Your intestines may also try to eliminate this overly concentrated solution so you may get cramps or diarrhea. Studies have shown that for most people exercising at moderate levels of exertion, a 6% to 8% simple carbohydrate solution is the maximum that can be tolerated. This is represented by A in Figure 5.

Doubling the concentration of a glucose solution from 6% to 12% will double the calories, but usually cause gastrointestinal upset. This is represented by B in the figure.

You may be able to pack more calories into a given fluid volume by combining a variety of sugars. A 6% fructose and 6% glucose solution, for example, may cause less gastrointestinal upset than a 9% solution of either of these simple sugars. Further, increased water and electrolyte movement from the gut into the bloodstream may take place, as different mechanisms of transport are involved with these two simple sugars.

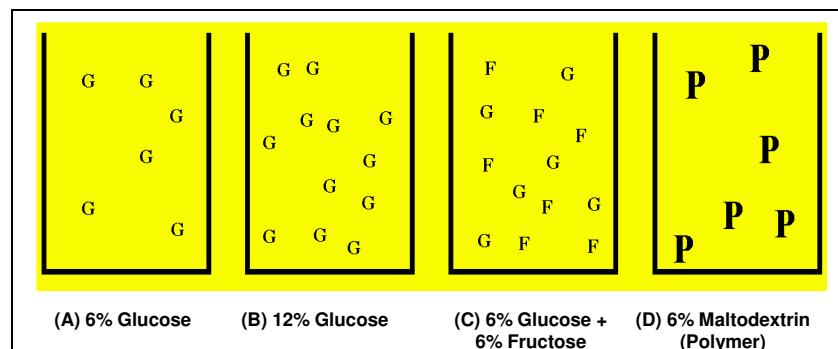


Figure 5. Energizing sugar solutions. About 6% solutions are generally well-tolerated. Increasing caloric content by increasing concentration (adding more scoops, B), or adding different types of sugars (C) generally does not work. Increasing particle size with maltodextrins (glucose polymers, D) is the winning strategy.

This is represented by C in the figure.

Improving gastrointestinal tolerance and maximizing uptake is not the same as maximizing muscle uptake. The muscles may also take up and use more carbohydrate if energy is supplied by more than one type of simple sugar.

At rest, athletes can eat or drink more calories than their muscles can process. At moderate to high intensity, muscles may be able to process more carbohydrate than most athletes can tolerably ingest.

You may be able to increase gastrointestinal tolerance and pack more calories into a given fluid volume by using maltodextrins, or glucose polymers. These glucose chains increase calories without increasing the number, or concentration, of particles. This is represented by D.

What Are Maltodextrins?

As discussed beginning on page 45, carbohydrates in nature are generally simple sugars or starches.

Food manufacturing processes can create intermediate length carbohydrate molecules much shorter than the thousands of sugars in starches, but longer than the one or two sugars in molecules of monosaccharides and disaccharides.

These intermediate-length carbohydrate molecules are called maltodextrins or glucose polymers.

Typically, these are about 10 sugar units long.

In general, the shorter the maltodextrin, the sweeter it is. Most 10-sugar molecule maltodextrins are almost tasteless. This allows food processors to use maltodextrins in savory foods or add sweetness, if desired.

A 6% simple carbohydrate solution will have about 100 calories in 16 ounces, a standard water bottle. A 6% maltodextrin solution will have about 600 calories in 16 ounces.

Using maltodextrins allows more calories to be ingested without causing the gastrointestinal distress associated with the higher osmotic load of concentrated simple carbohydrate solutions. That is one reason why many specialty sports products (drinks, gels, and bars) that aim to provide calories during exercise use maltodextrins.

Why Maltodextrins?

Maltodextrins are the fuel of choice for aerobic endurance athletes. They are:

- Caloric
- Carbohydrate
- Low osmolarity (particle concentration)
- Less likely to cause GI distress
- Minimal taste—use flavoring of choice
- Inexpensive

Better Maltodextrin?

Most commercially available high-carb sports drinks and gels contain maltodextrins mixed into proprietary formulas for taste and color. Other ingredients, for example vitamins or herbs, may be added—generally for marketing purposes.

A few specialty sports drinks that contain maltodextrins provide more than 400 calories per bottle. Examples include the proprietary products Extran and Carbo Gain.

For more information and a listing of selected sports drinks, see *Sports Drinks* on page 97.

Powdered products are generally less expensive than premixed solutions.

Powdered products sometimes have problems with dissolvability, palatability (taste), caking, or sludging.

Like many proprietary products, some commercial maltodextrins, especially those sold through beer-brewing stores, will cake.

Maltodextrins are available in different average simple-sugar chain lengths.

Agglomerated products (processed to yield crystal clumps) are dustless and free-flowing. They are easy to handle. Agglomerated maltodextrins have excellent dispersibility and dissolution characteristics, quickly forming clear solutions when mixed with water.

Make Your Own Maltodextrin Product

Why? It is:

- Less expensive
- Better tasting
- Easier to handle

Cost

You can make your own great solution inexpensively.

You can purchase a wide variety of pure maltodextrin products in 50-pound bags from commercial grain processors. The cost usually is less than \$1.00 per pound or one-tenth that of proprietary products. The bag generally has a shelf life of two years.

You can split a \$100 order (100 pounds)—generally enough for four riders for a year.

Taste

Maltodextrin is relatively tasteless; it has minimal sweetness.

Your own maltodextrin solution tastes better because you control the taste.

Generally, something with a little citric acid or tartness works best.

You can add a little lemonade, fruit juice, Kool-Aid, soda, to your own made-up solution for your personal favorite taste.

Maltodextrin solutions that contain more than 100 calories per standard 16-ounce waterbottle sometimes result in a filmy back-of-the-throat aftertaste. If this is unpleasant for you, reduce the concentration.

Handling

I use Maltrin QD 500. It has a slightly higher caloric content for the same osmotic load than other Maltrins.

It is agglomerated, virtually dustless.

The powder pours well. It pours easily into a waterbottle. This is valuable when filling a bottle of water from a feeder on the fly at an aid station or while racing.

The powder does not cake; the solution does not sludge. It dissolves quickly and completely.

This maltodextrin can dissolve 3 cups (24 fluid ounces) of powder into 2 cups (16 ounces) of fluid—not that I use that amount. This works out to about 1,000 calories per bottle.

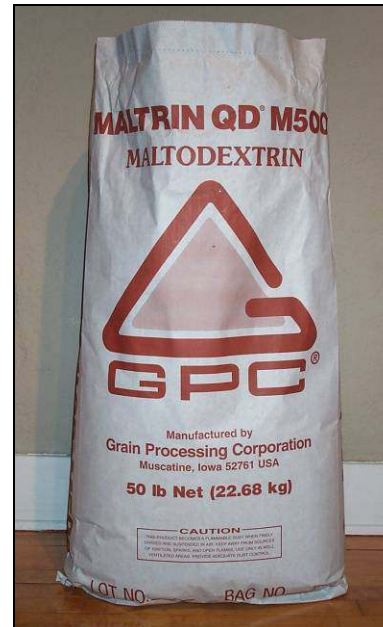


Figure 6. A 50-pound bag of Maltrin QD M500 from Grain Processing Corporation.⁷

⁷ Product Reference/Disclosure

I have no commercial interest in this company. I purchase the product at retail cost. The minimum order is \$100.

Product Information

<http://www.varied.com/food/maldescr.html>

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16141 Heron Avenue, La Mirada, CA 90638. Tel: 800-442-4676, Fax: 714-670-6851. Web site:

www.ethorn.com

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J. M. Swank Company, Inc.

520 West Penn Street, North Liberty, IA 52317. Tel: 800-593-6375, Fax: 319-626-3662. Web site:

www.jmswank.com

If I am planning on taking in only one 16-ounce waterbottle per hour, and no snacks, I mix one cup of maltodextrin in a 16-ounce bottle. This yields about 300 calories. I do not do this often.

If I plan to eat snacks, I usually reduce the amount of maltodextrin to about half this amount. I do this commonly.

If it is hot, I will drink two or more waterbottles per hour. Again, I will mix one-half a cup of maltodextrin, or less, in a 16-ounce bottle. This works out perfectly—as it is hot I will tolerate a lower concentration than when it is cooler—but I will still be able to average 300 calories of carbohydrate per hour because I will be drinking more.

Protein

Protein Key Points

- Aim to ingest 10% to 20% of calories from protein. The upper end of the range is for aerobic endurance athletes exercising more than 10 hours per week.
- Said differently, aim for up to 1.5 grams of protein per kilogram (0.7 grams per pound).
- Watch for bad company—substances harmful for health that may accompany otherwise good protein sources.
- Get a mix of proteins. A variety of foods will ensure that you get all of the amino acids you need.
- Balance carbohydrate and protein. Keep up the carbs. Endurance athletes need carbohydrate for intensity training.
- Too much protein can potentially weaken bones.
- There is little evidence that athletes need protein supplements.
- There is little evidence that amino supplements are of value, except in a few disease states.
- Whey protein has no magical qualities.
- The role of protein in recovery drinks, if any, is overstated.

Background

Protein, a basic structure material of all cells, is also biologically active in enzymes, immunoglobulins, hormones, neurotransmitters, nutrient transport and storage compounds, and cell membrane receptors.

Protein is needed for muscle formation. Enzymes are important in speeding up many body processes.

Proteins are made up of amino acid units. There are 22 common amino acids. They mix and match in thousands of different combinations to make up specific proteins.

The body cannot manufacture nine of these amino acids; it must get these essential amino acids from diet.

Requirements: RDA

The US Food and Nutrition Board (FNB) young adult daily RDA is 56 grams per day for men and 46 grams per day for women.

Growth, pregnancy, lactation, and exercise increase needs.

The FNB Acceptable Macronutrient Distribution Range is 10% to 35%.

Generally, 10% to 15% of total daily energy intake should be consumed as protein.

Requirements by Quality

The amount of protein needed to meet the requirements for indispensable amino acids differs depending upon the protein source.

Protein needs are minimal when the dietary protein is of high quality: it is highly digestible, and provides amino acids in the proportions in which they are required.

Requirements by Activity

Sedentary adults probably need less than 0.5 grams of high-quality protein per kilogram of body weight. A 60-kilogram (132 pounds) sedentary adult might do fine on just 30 grams of high-quality protein.

The RDA is higher, in part because not all protein is high-quality, not all is easily digestible, not all adults are sedentary, many weigh more than 60 kilograms, and some additional protein is added as a safety margin to cover individual differences.

Those engaged in recreational activities may use up to 0.8 grams per kilogram.

A few studies have shown that competitive endurance and strength athletes may use up to 1.5 grams per kilogram.

No studies have shown that more than 2 grams per kilogram, or 1 gram per pound, is of value.

Sources

Food

Meat, poultry, fish, dairy, and eggs are rich sources of high biological value protein. The protein content of cooked meat and dairy products is between 15% and 40%.

Plant sources of protein (legumes, nuts, and seeds) can contribute to protein requirements. The protein content of cooked cereals, beans, lentils, and peas ranges from 3% to 10%.

Protein content of selected foods is listed in Table 6.

Right Protein

The right protein is:

- 1) Enough
- 2) Good quality
- 3) Not overly linked with substances bad for health

For example, peas or gelatin contain protein, but the quality is poor.

Meat may be a good source of high quality protein, but bad if associated with lots of cholesterol and saturated fats.

Fish may be a good source of high-quality protein, but bad if associated with mercury or other toxins.

These concepts are discussed in more detail below, under, *Bad Company* on page 63.

Source	Serving Size	Protein, grams
Beef, round steak, cooked	3 ounce	27.0
Ground beef, cooked	3 ounce	25.7
Turkey breast	3 ounces	25.7
Veggie burger	3 ounce	25.7

Source	Serving Size	Protein, grams
Pork chop, cooked	3 ounces	24.5
Turkey, dark meat	3 ounces	24.3
Chicken, dark meat	3 ounces	23.6
Tuna, water packed	3 ounce	22
Chicken breast	3 ounces	18.9
Salmon, cooked	3 ounce	16.8
Cheese pizza	2 slices	15.4
Cheese, cottage, 1% fat	½ cup	14.0
Yogurt, low-fat	1 cup	11
Lentils, cooked	½ cup	9.0
Milk, fat-free	8 ounces	8.3
Peanut butter	2 tablespoons	8.1
Milk, whole	8 ounces	8.0
Split peas, cooked	½ cup	8.0
Beans, black-pinto-garbanzo	½ cup	7.5
Cheese, American	1 ounce	7.0
Tofu	3 ounces	7.0
Macaroni, cooked	1 cup	6.8
Milk, soy	8 ounces	6.7
Egg	1 large	6.3
Ham	1 ounces	5.9
Almonds	1 ounces	5.4
Bread, wheat or white	2 slices	5.2
Ice cream, regular	1 cup	5.0
Green peas, cooked	½ cup	4.1
Corn, cooked	½ cup, or 1 ear	2.5
Rice, cooked	½ cup	2.2
Orange	1 large	1.7
Banana	1 medium	1.2
Potatoes, white	½ cup	1.2
Green beans, cooked	½ cup	1.0
Carrots, cooked	½ cup	0.8
Apple	1 large	0.0

Table 6. Protein content of selected foods.

Essential vs. Nonessential Amino Acids

The building blocks of human proteins are 22 amino acids. These may come from both animal and plant sources.

Nine amino acids are essential, or indispensable, because they cannot be synthesized by humans.

The 22 amino acids are listed in Table 7 and tabulated according to essentiality.

Nonessential amino acids can be biosynthesized by the transfer of amino groups to carbon compounds that are formed as intermediates of glucose (glucogenic amino acids) and lipid (ketogenic amino acids) metabolism.

Essential	Conditionally Essential	Nonessential
Histidine	Arginine	Alanine
Isoleucine	Asparagine	Aspartic acid
Leucine	Cysteine*	Cystine
Lysine	Glutamine	Glutamic acid
Methionine	Serine	Glycine
Phenylalanine	Taurine	Proline
Threonine	Tyrosine*	
Tryptophan		
Valine		

Table 7. Essential, conditionally essential, and nonessential amino acids. *Cysteine is sometimes considered essential together with methionine; as is tyrosine with phenylalanine.

Methionine and phenylalanine are required as precursors for the synthesis of the amino acids cysteine and tyrosine respectively.

For this reason, methionine and cystine are sometimes considered together as essential, as are phenylalanine and tyrosine.

Nonessential amino acids may become conditionally essential.

Ordinarily nonessential amino acids may not be synthesized in large enough amounts to meet the body's needs if the metabolic pathways for their synthesis are immature or impaired.

For example, cysteine, tyrosine, and possibly taurine may be required for premature infants. After trauma or surgery, glutamine may not be synthesized in adequate amounts.

Biological Quality

The biological quality of a dietary protein is determined by:

- 1) The amount
- 2) The proportion of essential amino acids it provides
- 3) Digestibility

If a protein contains a disproportionately low amount of one or more amino acids or is not completely digested, the amount needed to meet protein requirements will be greater than that of a protein that has a well-balanced pattern of amino acids and is highly digestible.

If any of the essential amino acids is not available in sufficient amounts relative to other essential amino acids, protein synthesis will be limited.

If any of the essential amino acids is present in excessive amounts relative to other essential amino acids, it will be wasted relative to protein synthesis.

Other body proteins, such as albumin, may be broken down to provide limiting amino acids so that protein synthesis may continue.

Animal Protein

Protein from most animal sources (meat, fish, dairy, and eggs) is considered to have high biological value or to be *complete* because all nine essential amino acids are present in good proportion in these proteins.

Gelatin, an exception to high-quality animal protein, is of low-quality; it lacks tryptophan.

Plant Protein

Plant sources of protein (grains, legumes, nuts, and seeds) are generally deficient in one or more essential amino acids.

The exception is the soybean; all essential amino acids are present.

Protein synthesis occurs only to the extent that the limiting amino acids are available.

If they are relatively low, but not lacking in a limiting amino acid, they can meet the requirements for essential amino acids if ingested in large quantities.

Different plant proteins can also be combined to provide amounts and proportions of essential amino acids equivalent to high biological proteins from animal sources. This is discussed in more detail below.

Such proteins are considered to have intermediate biological value or to be *partially complete*.

Plants that are entirely lacking in one or more essential amino acids are considered of low biological value or to be *incomplete*. These sources include most fruits and many vegetables.

A low biological value also means that it is difficult or impossible to compensate for insufficient amounts of essential amino acids by combining different sources as with partially complete proteins.

Examples of high-, intermediate-, and low-quality proteins are listed in Table 8.

High/Complete	Intermediate/Partially Complete	Low/Incomplete
Milk, cow	Soy	Peas
Eggs, chicken	Sunflower seeds	Cornmeal
Milk, human	Rice	Flour, white wheat
Beef	Potatoes	Cassava
Fish	Oats	Gelatin
	Peanut butter	
	Beans	

Table 8. Protein quality. Examples of high-, intermediate-, and low-quality proteins.

Combining Complementary Proteins

Vegetarians and others often depend upon incomplete proteins such as nuts, grains, and legumes.

By eating a balanced diet of grains and legumes with each meal or over the course of each day incomplete proteins can be combined to provide all amino acid requirements.

For example:

- The amino acids from beans taken at one meal can complement the amino acids from rice eaten at another meal that day.
- Macaroni complements cheese. The essential amino acids from the cheese allow the body to better use the amino acids in the macaroni.
- Peanut butter complements wheat bread.

Amino Acid Score

The amino acid balance concept:

- Protein synthesis is limited unless all amino acids are present in appropriate amounts.
- Protein synthesis is limited by the essential amino acid present in the least amount in relation to the amount required.

Partially Complete Protein Example

Proteins of most cereal grains are low in lysine. If the lysine content of a whole-wheat flour is 2.6% and the value for lysine in the scoring pattern based on the amino acid needs of the young child is 5.8%, the amino acid score for lysine in wheat proteins is $2.6/5.8 \times 100 = 45$.

The scores for all other amino acids are higher, so lysine is the limiting amino acid. The amino acid score for wheat proteins is 45.

The score for whole egg proteins is 100.

To meet the requirement for lysine, a young child would have to consume more than twice as much protein from whole wheat as from whole egg.

Scores Change With Age

Both protein and amino acids requirements are higher, in milligrams per kilogram of body weight, at birth than as we mature.

Amino acid requirements, in milligrams per kilogram of body weight, decline relatively more rapidly with increasing age than protein requirements.

A protein that may not meet the indispensable amino acid requirements of a child when consumed in an amount that meets the total nitrogen requirement may provide amounts of amino acids in excess of the requirements of an adult.

For example, during the first two years of life, lysine requirements decline from 5.8% of protein to 1.6%, more than one-thirds, while the protein requirement declines by half.

The partially complete whole-wheat flour, with a 2.6% value for lysine, will have a 100 amino acid score for adults.

The Food and Agriculture Organization (FAO)/World Health Organization (WHO) amino acid scores are most commonly used. Other groups' values may be as much as 20% lower or higher.

Amino acid	Requirement				Composition ¹		
	Milligrams per gram crude protein						
	Infant ²	2-5 yrs	10-12 yrs	Adult	Egg	Milk, cow	Beef
Histidine	26	19	19	16	22	27	34
Isoleucine	46	28	28	13	54	47	48
Leucine	93	66	44	19	86	95	81
Lysine	66	58	44	16	70	78	89
Methionine & cysteine	42	25	22	17	57	33	40
Phenylalanine & tyrosine	72	63	22	19	93	102	80
Threonine	43	34	28	9	47	44	46
Tryptophan	17	11	9	5	17	14	12
Valine	55	35	25	13	66	64	50
Total	460	339	241	127	512	504	479

Table 9. Amino acid requirements and composition of high-quality animal proteins, from FAO/WHO/UNU (1985).

¹Composition from Lunven *et al.*, 1972. ²Based on breast milk.

Adults Less Concerned About Quality

As can be seen in Table 9, a minimum of 460 milligrams out of every 1,000 milligrams must contain essential amino acids for infants in order for protein to be of the highest quality.

The proportion of essential protein to the total protein requirement falls from 46% for infants to about 13% for adults.

This is the basis for the conclusion of the FAO/WHO/UNO committee that only digestibility, not protein quality, need be considered in estimating protein needs of adults.

This does not apply to young children, whose indispensable amino acid requirements are several times those of adults.

Function

Structure

Protein is a basic structural material of all cells. The structural proteins of muscles make up the largest proportion of total-body proteins.

Biologic Activity

Biologically active proteins include enzymes, immunoglobulins, hormones, neurotransmitters, nutrient transport and storage compounds, and cell membrane receptors.

Plasma proteins (e.g., albumin) contribute to oncotic pressure that directs the flow of fluid and metabolic waste from the intracellular compartment into the capillary venules. These proteins (e.g., hemoglobin) also contribute to plasma buffering capacity and oxygen-carbon dioxide transport (e.g., hemoglobin, myoglobin).

Acute phase reactant proteins (e.g., ferritin, prealbumin) secreted by the liver bind minerals such as iron and zinc rendering them unavailable to support microbial proliferation.

Many small nitrogen-containing molecules needed for normal body functions are synthesized from amino acids. Some of the individual amino acids are precursors of the purines and pyrimidines needed for the synthesis of nucleic acids, the hereditary units that carry information from one generation to the next.

Other amino acids are precursors of small biologically important molecules such as heme, small hormones such as thyroxine and epinephrine, creatine, neurotransmitters, skin pigments, and nitrogenous constituents of phospholipids.

Some amino acids serve as stimuli for the release of hormones from endocrine organs and the gastrointestinal tract.

Several of these amino acids, particularly leucine, glutamine, and arginine, are used as therapeutic agents in the treatment of patients in catabolic states or with hepatic encephalopathy.

Energy Production—Oxidation

Proteins can break down to provide energy: four calories per gram.

Organs and tissues differ greatly in their ability to use amino acids as energy sources. The liver has the capacity to oxidize most amino acids and, if they are in surplus, will oxidize them in preference to other energy-yielding molecules.

Most of the essential amino acids are not oxidized in other tissues. The branched-chain amino acids—leucine, isoleucine, and valine—like many of the dispensable amino acids, can be oxidized by most tissues and organs.

Glutamine and glutamic acid are preferred energy sources for the intestine and lymphocytes.

Deficiency

In the US and other developed countries, it is generally easy to get the minimum daily requirement of protein. Deficiencies usually result from disease or eccentric diets.

Cereal with milk for breakfast, a peanut butter and jelly sandwich for lunch, and a piece of fish with a side of beans for dinner adds up to about 70 grams of protein, plenty for the average adult.

Around the world, millions of people do not get enough protein. Protein malnutrition leads to the condition kwashiorkor.

Kwashiorkor can cause growth failure, loss of muscle mass, decreased immunity, weakening of the heart and respiratory system, and death.

The most common cause of protein deficiency is insufficient energy intake, which is exacerbated when demand for both protein and energy is high.

Protein energy malnutrition signs and symptoms include: weight loss, diarrhea, loss of lean body mass, muscle weakness,

depigmented hair and skin, pressure sores, and depressed immune function.

Amino Acids For Disease Treatment

A few amino acids have been studied as therapeutic agents.

Tryptophan

Adults require about 250 milligrams daily for protein synthesis.

Doses greater than 1 gram daily (four times the daily requirement) induce sleep.

Tryptophan as a pharmacological agent has been associated with toxic effects, probably due to supplement contaminants.

Branched-Chain Amino Acids (Leucine, Isoleucine, Valine)

Intravenous solutions are used to improve nitrogen retention in septic and uncomplicated postoperative patients.

Branched-chain amino acids along with lowered amounts of the aromatic amino acids may be helpful in hepatic encephalopathy.

Arginine

Arginine stimulates the release of hormones including growth hormone and insulin.

Arginine, in doses as high as 30 grams per day, reduces nitrogen loss in surgical patients with moderate trauma and improves lymphocyte function in healthy subjects.

Glutamine

Glutamine is conditionally essential in critically ill patients.

It is a preferential energy source for the intestinal mucosa and is used extensively for energy by lymphocytes when they are stimulated to proliferate.

It has been tested in doses to 40 grams per day.

Other Health Claims

Weight Control

In short-term studies, a diet that includes more protein and less carbohydrate may be more effective for losing weight or keeping weight steady than a high-carbohydrate diet. This is due, in part, to loss of storage glycogen, which binds about three times its weight in water.

Long-term effects are less certain.

Cardiovascular Disease

One large, prospective study has investigated the association between dietary protein and heart disease or stroke.

In the Nurses' Health Study, over a 14-year period, women who ate the most protein (about 110 grams per day) were 25 percent less likely to have a heart attack or to die from heart disease than women who ate the least (about 68 grams per day).

Cancer

There is no evidence that a little or a lot of protein influences cancer risk.

Toxicity

The average American consumes about 100 grams of protein per day—almost twice the recommended daily allowance (RDA) of 50 grams for women and 63 grams for men.

Dietary protein consumed in excess of requirements is not stored.

It is deaminated (nitrogen is removed) followed by either:

1. Oxidation (use as energy) of the carbon skeleton through pathways of glucose or fat metabolism, or
2. Stored as glycogen or fat, depending upon the specific amino acid and the energy balance at the time.

Nitrogen waste is excreted in the urine as either urea or ammonia.

The digestion of protein releases acids that the body usually neutralizes with calcium and other buffering agents in the blood. High protein intakes can increase urinary calcium excretion. The effect on calcium balance is controversial since amino acids also increase the efficiency of intestinal absorption.

In the Nurses' Health Study, women who ate more than 95 grams of protein a day were 20 percent more likely to have broken a wrist over a 12-year period when compared to those who ate less than 68 grams a day.

The relationship of long-term high protein intakes to liver disease, kidney disease and diabetic nephropathy is controversial and uncertain.

Bad Company

A 6-ounce untrimmed T-bone steak provides 40 grams of high-quality protein. It also delivers 38 grams of fat, 15 of them saturated—almost three-fourths of the daily allowance for saturated fat.

A pint (16 ounces) of whole milk provides 300 calories; 16 grams of protein, 24 grams of carbohydrate, and 16 grams of fat. Fat calories account for 47% of total calories. Depending upon the brand, about 60% of fat calories are saturated.

A pint (16 ounces) of fat-free milk provides 172 calories; 16 grams of protein, 24 grams of carbohydrate, and 0.8 grams of fat. Fat calories account for 5% of total calories.

Six ounces of swordfish provides 44 grams of protein but only 9 grams of fat, 2 of them saturated. However, methylmercury levels are high, 1 part per million. Six ounces deliver almost an entire weekly safe allowance of methylmercury.

A cup of cooked lentils has 18 grams of protein, less than 1 gram of fat, and negligible contaminants.

Allergy

Proteins in food may cause allergic reactions including hives, cardiovascular collapse, and death.

Relatively common culprits include peanuts and shellfish.

Diabetes

Some evidence shows that proteins found in cow's milk may play a role in the development of type I diabetes, perhaps on an immune or allergic basis.

Athletic Considerations

Protein

Many athletes, particularly those involved in strength training, believe that to build muscle you need more protein. Almost all Americans get more than enough.

Exercise, not extra protein, is the way to increase muscle size and strength.

Excess protein does not build muscles. It is either burned as energy or stored—not as muscle, but as fat.

Endurance athletes have a higher requirement than most body-builders due to protein breakdown and losses of lean body mass following aerobic exercise.

The FNB adult daily RDA is about 0.75 grams per kilogram (0.35 gram per pound). Studies support up to a maximum of twice that amount, 1.5 grams per kilogram (0.7 grams per pound), for full-time aerobic endurance athletes.

This increased requirement can be readily met without supplementation with the high caloric intakes required by athletes.

Amino Acid Supplements

Amino acids are the building blocks of protein. If you consume good quality protein in your diet, you are probably getting many times the amounts hyped in most supplements.

Amino acid supplements may interfere with synthesis of body protein by creating imbalances. Amino acids compete for absorption; large quantities of free amino acids at the intestinal mucosal surface reduce the amount that can be absorbed from the available supply.

A large US nutritional retailer was fined \$2.4 million by the Federal Trade Commission for promoting free-form amino acids as a stimulator of growth hormone production.

There is little evidence that any amino acids or biochemical enzyme supplements have any value. Here is a brief summary of some amino acids studies of the last decade:

Amino acid supplement was found to reduce some hormonal changes associated with overtraining in a study sponsored by the manufacturer.

Amino-Vital, a proprietary product, was shown to have mixed performance effect in 30 female college students. These students were fed 30 minutes before exercise with branched chain amino acids. Unfortunately, the placebo group received no calories. After three months of steady supplementation, no effect on aerobic capacity was found.

Arginine in a dose of 5 grams increased growth hormone levels.

Branched-chain amino acids are purported to be a fuel source, to decrease tryptophan uptake by the brain, to change serotonin levels in the brain, or to improve immunity. The brain hormone level changes are supposed to reduce exercise fatigue. Roughly 1 study out of 10 has found marginal benefit.

Citrulline malate: This is an amino acid found in watermelon and milk protein. Improved aerobic capacity was found in one study.

Leucine supplementation: No effect on performance.

Methionine: No change in strength was found in 21 well-trained weight lifters.

Tyrosine, an amino acid and dopamine precursor, added to carbohydrate was found not to improve cycling performance.

Bottom Line

Review the key points.

Aim for good quality protein intake up to a maximum of 20% of calories or 1.5 grams of protein per kilogram (0.7 grams per pound).

Whey Protein

Description

Whey proteins are one of the two major protein groups in cow's milk; the other group is the caseins.

Caseins account for about 80% of the protein; whey for 20%.

Whey is a byproduct of cheese making.

Whey proteins, like caseins, are high-quality proteins.

The main whey proteins, beta-lactoglobulin and alpha-lactoglobulin, account for 70% to 80% of total whey protein.

Proteins present in lesser amounts include immunoglobulins IgG, IgA and IgM; glycomacropeptides; bovine albumin; lactoferrin; lactoperoxidase; and lysozyme. Whey also contains smaller peptides.

Raw whey also contains fat and lactose. It is processed to produce whey protein concentrates and whey protein isolates.

Whey protein concentrates are rich in proteins; they also contain fat and lactose. Whey protein isolates are low in fat and lactose.

Function

Whey proteins may have antimicrobial, immunomodulatory, anticancer, and antioxidant activity. Such effects are not well-established and are based mainly on animal research.

There is no credible evidence that whey proteins build muscle faster than other protein sources.

Infants

Whey proteins are used as the sole proteins in some infant formulas, and this may result in fewer allergies in these infants.

Soy Protein

The US FDA allows food labels to claim that soy can help reduce the risk of heart disease on low-fat foods containing at least 6.25 grams of soy protein.

Theory or modest research suggests that soy-based foods chill hot flashes, prevent breast and prostate cancer, aid weight loss, and prevent osteoporosis. These effects may be due to their high concentrations of isoflavones—phytoestrogens or plant-made estrogens.

As is often the case, marketing claims go beyond the available evidence.

Heart Disease

Soy lowers cholesterol levels.

A 1995 meta-analysis of 38 studies showed about 50 grams of soy protein daily in place of animal protein reduces total cholesterol by 9.3%, LDL cholesterol by 12.9%, and triglycerides by 10.5%.

50 grams of soy protein is the equivalent of 1½ pounds of tofu or eight 8-ounce glasses of soymilk.

The American Heart Association recommends including soy-based foods as part of a heart-healthy diet.

Hot Flashes

Soybeans are rich in phytoestrogens that could theoretically reduce menopausal symptoms including hot flashes.

Research has not found this benefit.

Breast Cancer

Studies are mixed.

Toxicity

Soy is not without potential problems. Studies suggest that soy protein supplements may:

- Stimulate the growth of breast cancer cells.
- Lead to memory problems.

Protein For Recovery?

Most sports drinks, fruit juices, and sodas contain carbohydrate as their almost exclusive source of calories.

Some coaches and nutritionists advocate adding protein to recovery drinks, generally to speed glycogen replacement.

Is the addition of protein to sports drinks helpful in promoting recovery? Should you use a sports drink with protein?

You will find details of the science underlying the answers to these questions below. The details are somewhat technical. If you prefer, skip to the summary on 73.

What We're Talking About

Protein as a Macronutrient

As discussed beginning on page 56, protein, a basic structure material of all cells, is also biologically active in enzymes, immunoglobulins, hormones, neurotransmitters, nutrient transport and storage compounds, and cell membrane receptors.

Proteins may also be used by the body for energy or converted to and stored as fat. When metabolized in this way, protein is expensive: It costs more than carbohydrate. Expensive protein supplements are usually a waste of money.

Some have suggested that endurance athletes consume protein up to 1.5 grams per kilogram or 0.75 grams per pound of body weight.

Since endurance athletes consume more calories, if they eat a balanced diet it is easy to meet and exceed these daily recommendations.

Protein as an Aid in Recovery

We are not interested in debating the overall daily protein requirement here. We are interested in looking at whether the timing of protein consumption is important.

What we will address here is whether protein is an important component of recovery drinks or should be part of a specific recovery strategy after exercise.

At the heart of this issue is whether ingesting protein early in the recovery process improves glycogen replenishment.

Carbohydrate Fuels Muscles

As discussed on page 43, muscles are fueled by carbohydrate and fat.

Since about the 1960s, it has been known that the higher the intensity of work, the more carbohydrate is burned.

Carbohydrate is supplied from stores in muscles as glycogen and from the blood stream.

With prolonged moderate- or high-intensity exercise, glycogen stores can be exhausted. Until these glycogen stores are replaced, the athlete's ability to exercise repeatedly at moderate or high intensity is limited.

Sparing Glycogen

Athletes can supply carbohydrate to working muscles by eating or drinking carbohydrate while exercising. Ingested carbohydrate travels through the blood stream as simple sugar—for example, glucose—to muscles.

Studies have shown that fueling muscles by ingesting carbohydrate can spare muscle glycogen.

There is a practical limit as to how much carbohydrate can be ingested to fuel working muscles. This appears to be roughly 300 carbohydrate calories per hour, 1.2 grams of carbohydrate per

kilogram of body mass, 0.5 grams per pound of weight, or 2 calories per pound.

Replacing Glycogen

It is widely accepted that athletes who consume carbohydrate relatively promptly after exercise, during a *glycogen window*, replace muscle glycogen more efficiently than those who delay eating.

Again, there is a limit as to how quickly carbohydrate can be replaced. This also appears to be at the rate of roughly 300 carbohydrate calories per hour, or 1.2 grams of carbohydrate per kilogram of body mass, 0.5 grams per pound of weight, or 2 calories per pound.

Here are details about the science and about the hype:

Protein Replacement Half Truth

Van Loon et al, AJCN, 2000⁸

Luc JC van Loon et al published an often-quoted study in the American Journal of Clinical Nutrition, July, 2000.

This research is quoted to prove that protein helps recovery. The heading *Half Truth* refers not to researcher van Loon, but to how his research has been manipulated in advertising.

The study was based on eight subjects.

Van Loon compared (a) a carbohydrate recovery drink to (b) the same carbohydrate drink plus one-half again as many protein calories.

⁸ Van Loon, L.J.C., et al. (2000). Maximizing postexercise muscle glycogen synthesis: carbohydrate supplementation and the application of amino acid or protein hydrolysates mixtures. The American Journal of Clinical Nutrition. 72(106). http://www.ajcn.org/cgi/reprint/72/1/106?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=1&author1=Loon&andorexacttitle=&andorexacttitleabs=&andorexactfulltext=&andsearchid=1101346278391_18141&stored_search=&FIRSTINDEX=0&sortspec=relavance&journalcode=ajcn. Accessed 11-25-2004.

Subjects were fed carbohydrate at the rate of 0.8 grams per kilogram per hour, every 30 minutes, for 5 hours.

For example, a 70-kilogram, 154-pound subject would have received 28 grams (112 calories) of carbohydrate every 30 minutes.

On another occasion, in addition to receiving the same amount of carbohydrate, protein was added in the amount of 0.4 grams per kilogram per hour (0.2 grams per kilogram every 30 minutes).

For example, a 70-kilogram, 154-pound subject would have received 28 grams (112 calories) of carbohydrate and 14 grams (56 calories) of protein every 30 minutes.

Synthesis of muscle glycogen was the endpoint.

Protein helped, as is dramatically illustrated in Figure 7, taken from the study. This group fared much better when receiving carbohydrate and protein than when given carbohydrate alone.

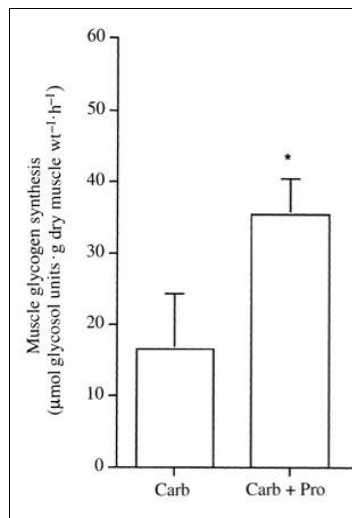


Figure 7. van Loon et al. AJCN 72(1) 106.
Half-truth. Carbohydrate and protein were shown to result in more glycogen synthesis than carbohydrate alone.

Figure 7 was widely reproduced, for example, on commercial websites promoting Endurox R4.

The full truth is that researcher van Loon examined the group a third time.

Instead of adding protein, though, this third time the group received additional carbohydrate. The additional carbohydrate, 0.4 grams per kilogram, was the same amount calorically as the additional protein received by the group when protein was added.

For example, a 70-kilogram, 154-pound subject would have received 42 grams (168 calories) of carbohydrate every 30 minutes.

With additional carbohydrate, the subjects did the best.

That is to say when the amount of calories given was the same, carbohydrate worked better than a mixture of carbohydrate and protein. This is illustrated in Figure 8.

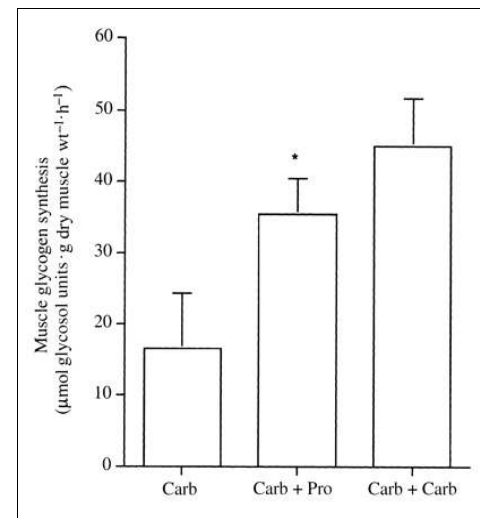


Figure 8. van Loon et al. AJCN 72(1) 106.
Full-truth. Carbohydrate given in equal caloric amounts to carbohydrate and protein were shown to result in greater glycogen synthesis than carbohydrate and protein.

Many commercial sport drink promoters completely ignored and continue to ignore this part of van Loon's research in promoting their protein-recovery products.

Summary: van Loon

Important conclusions of this study are:

1. Carbohydrate in the amount of 1.2 grams per kilogram per hour is better than 0.8 grams per kilogram per hour.
2. When subjects receive the same amount of calories, straight carbohydrate is better at replacing muscle glycogen than a mixture of carbohydrate and protein.

Protein Replacement Partial Truth

Zawadzki et al, JAP, 1992⁹

In an earlier study, Zawadzki also showed that the addition of protein was helpful in improving glycogen storage.

Glycogen replacement was faster with carbohydrate and protein than with either carbohydrate or protein alone.

Nine subjects were evaluated on three separate occasions. The study compared (a) 112 grams of carbohydrate—448 calories; (b) 112 grams of carbohydrate and 40.7 grams of protein—611 calories; and (c) 40.7 grams of protein—163 calories given after two hours of exhaustive cycling in a laboratory.

Muscle glycogen was examined immediately and four hours after exercise.

As in van Loon's study, the fundamental flaw in the study is that there was no (152.7 gram) carbohydrate group receiving the same number of total calories (611) as the carbohydrate-protein group.

⁹ Zawadzki, K.M., et al. (1992). Carbohydrate-protein complex increases the rate of muscle glycogen storage after exercise. *Journal of Applied Physiology*. 72(1854). View the abstract at: <http://jap.physiology.org/cgi/content/abstract/72/5/1854>. Accessed 11-25-2004.

Yes, carbohydrate and protein were better than either carbohydrate or protein alone; but more calories were given. We do not know whether subjects given the same total amount of calories in the form of carbohydrate would have fared even better, as they did in van Loon study.

Ed Burke's Optimal Muscle Recovery

Putnam, 2nd edition, 2003

This book popularizes the notion that protein is important in "restoring, protecting, and rebuilding muscles" during and after exercise.

Ed Burke, the author, was the trademark owner of R4.¹⁰ He was paid by PacificHealth Laboratories before his death from a heart attack in 2002.

Burke wrote this book to bring his thesis to a wider audience. He also had a commercial conflict of interest.

PacificHealth Laboratories, Inc.

Protein recovery drink research has been fueled by PacificHealth Laboratories. As of February 19, 2004, the company website notes.¹¹

"The sports nutrition category, which encompasses sports drinks, protein powders and supplements, and sports bars, exceeds \$2 ½ billion in annual sales. The largest component of this market is sports drinks, which is dominated by Gatorade and similar type products.

Gatorade type products are primarily for rehydration. In the past 10 years, landmark studies have shown that nutrition can improve athletic performance beyond rehydration.

PHL's sports nutrition research program has focused on enhancing recovery of the muscle during and after exercise. In developing products and conducting trials the Company uses a number of prominent experts in exercise physiology including:

¹⁰ <http://tess2.uspto.gov/bin/showfield?f=doc&state=7vjevs.2.12>. Accessed 2-19-2004.

¹¹ http://www.pacifichealthlabs.com/research_focus.asp. Accessed 2-19-2004.

- Dr. Edmund R. Burke Ph.D., Professor of Exercise Physiology, University of Colorado at Colorado Springs.
- Dr. Peter B. Raven, Ph.D., Professor of Exercise Physiology, Cardiovascular Research Institute, University of North Texas Health Science Center.
- Dr. John L. Ivy, Ph.D., Professor, Department of Kinesiology, University of Texas at Austin.
- Dr. John Seifert, Professor of Exercise Physiology, Human Performance Lab, St. Cloud State University.”

Protein Replacement Uncertain Truth

*Ivy et al, JAP, 2002*¹²

In an article published in the Journal of Applied Physiology, John Ivy might have shown that protein helps glycogen recovery.

John Ivy has received a \$45,000 grant from PacificHealth Laboratories (Endurox R4) for research.¹³

Seven subjects were studied on three occasions.

This study purported to measure glycogen replenishment after (a) a carbohydrate-protein (CHO-PRO) supplement, (b) a supplement of the same amount of carbohydrate (low carbohydrate, LCHO), and (c) a supplement with the same caloric content as the carbohydrate-protein mixture (high carbohydrate, HCHO).

Muscle glycogen was measured by nuclear magnetic resonance spectroscopy, not by traditional muscle biopsy.

The three supplements were given in two feedings: immediately after exercise and two hours post exercise.

The results of the study are illustrated in Figure 9.

There are at least three problems with this study:

1. How Much Fat?

The study muddies past research because all supplements contained some fat. How much fat is unclear.

The abstract says each of the two carbohydrate supplement feedings (LCHO and HCHO) contained 6 grams of fat. However, in the body of the article it is reported that subjects in the carbohydrate trials received only 3 grams of fat per supplement feeding. This difference would mean that groups were not isocaloric; the protein-carbohydrate group would have received an additional 54 calories.

I asked researcher Ivy about this in an e-mail. He replied: “The subjects received a total of 6 g of fat; 3 g with each CHO supplement. We weighed out the fat supplements in 3 g amounts (in a little paper cup).”

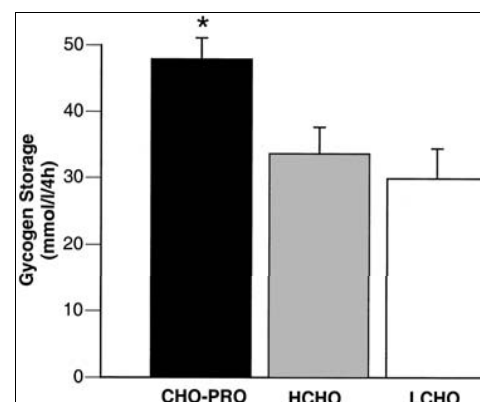


Figure 9. Ivy. JAP, 2002.

Total muscle glycogen storage in the vastus lateralis during 4 h of recovery from intense cycling. Treatments were with CHO-PRO, LCHO, and HCHO supplements provided immediately after and 2 h after exercise. *Significantly different from HCHO and LCHO ($P < 0.05$).

Since the carbohydrate-protein group received a drink with fat mixed in, and the carbohydrate group received fat supplements in

¹² Ivy, J.L., et al. (2002). Early post exercise muscle glycogen recovery is enhanced with a carbohydrate-protein supplement. Journal of Applied Physiology. 93(1337). http://jap.physiology.org/cgi/reprint/93/4/1337?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&author1=ivy&searchid=1101345093806_9463&stored_search=&FIRSTINDEX=0&sortspec=relevance. Accessed 11-25-2004.

¹³ <http://www.utexas.edu/education/kinesiology/exerphysio/ivy.html>. Accessed 2-19-2004.

paper cups, Ivy's response also implies that this was not a blinded study. The researchers knew which athletes were receiving which supplement.

2. How Many Calories?

The article is inconsistent in reporting caloric content.

For example, the article states that the carbohydrate-protein group received 80 grams of carbohydrate, 28 grams of protein, and 6 grams of fat for a subtotal of 378 calories on each of two occasions for a total of 756 calories.

There are 4 calories for every gram of carbohydrate and protein; there are 9 calories for every gram of fat. The expected subtotal per feeding is 486 calories; the expected total is 972 calories.

Where are the missing 216 calories?

Again, I contacted the study author. Ivy wrote:

"You are correct; the calculations of kcal per supplement and fat provided are confusing and incorrect. With regard to the kcal per supplement, your calculations are correct. The CHO/PRO and HCHO supplements should each total 486 kcal. How... miscalculated the kcal per supplement, I do not know... we should have caught these mistakes."

3. Not Enough Calories?

The total amount of carbohydrate calories given was inadequate according to other studies in literature.

If 160 grams of carbohydrate were given before the 4-hour glycogen replenishment examination took place, this equates to 40 grams per hour, or 160 calories.

This is about half the 1.2 grams per kilogram per hour (roughly 300 calories per hour for a 135-pound athlete) that van Loon and others have shown to be optimal.

Summary: Ivy

We do not really know.

A researcher, paid by a nutritional supplement company, published a non-blinded study of seven subjects in which methodological or reporting errors make interpretation impossible.

We do not know, with any certainty, how many calories of carbohydrate, protein, or fat any of the groups received. The carbohydrate-protein group may have received more calories. The total amount of calories received by all groups was probably low.

No Effect of Additional Protein

Van Hall et al, JAP, 2000¹⁴

Five volunteers were studied on three occasions.

They received one of three drinks: (a) carbohydrate-protein, (b) carbohydrate alone, or (c) water.

The results of the study are illustrated in Figure 10.

Subjects ingested 600 milliliters immediately after exercise and then 150 milliliters every 15 minutes for 4 hours.

The solutions contained (a) 1.67 gram sucrose per kilogram per liter of body weight and 0.5 grams whey protein per kilogram per liter, (b) 1.67 gram sucrose per kilogram, or (c) water.

Since subjects received 600 milliliters per hour after the initial bolus, they received (a) 1 gram per kilogram per hour of sucrose and 0.3 gram per kilogram of protein or (b) 1 gram per kilogram per hour of sucrose or (c) no calories.

¹⁴ Van Hall, G., et al. (2000). Muscle glycogen resynthesis during recovery from cycle exercise: no effect of additional protein ingestion. *Journal of Applied Physiology*. 88(1631). http://jap.physiology.org/cgi/reprint/88/5/1631?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&author1=hall&andorexactfulltext=and&searchid=1101345615095_9490&stored_search=&FIRSTINDEX=0&sortspec=relevance&volume=88&resourcetype=1. Accessed 11-25-2004.

Muscle biopsies were analyzed for glycogen immediately after exercise, at 1.5 hours, and at 4 hours post exercise.

No differences could be observed between carbohydrate-protein and carbohydrate trials.

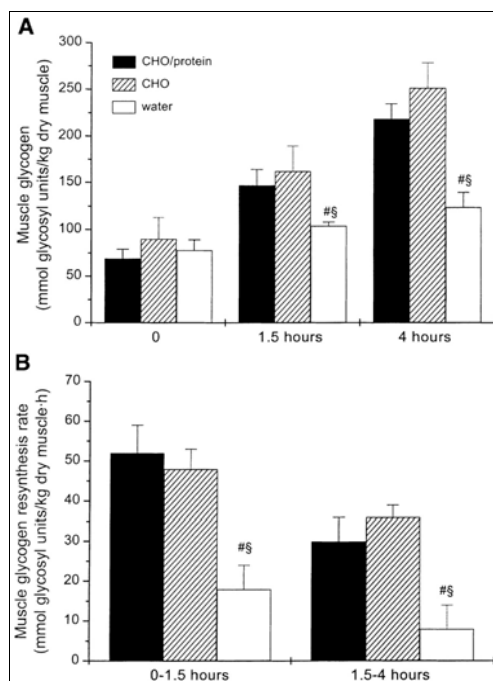


Figure 10. Van Hall et al. JAP 88(5) 1631. 2000.
Leg muscle glycogen concentration and muscle glycogen resynthesis rate during recovery from intense exercise. Muscle glycogen content (A) and muscle glycogen resynthesis rate (B) in vastus lateralis muscle during 4 h of recovery from intense cycle exercise. Values are means $\pm$ SE of 5 subjects.

#Significant differences from CHO/protein trial, $P < 0.05$.

§Significant differences from CHO trial, $P < 0.05$.

No Effect of Additional Protein and Amino Acids

Jentjens et al, JAP, 2001¹⁵

Eight cyclists performed two experimental trials.

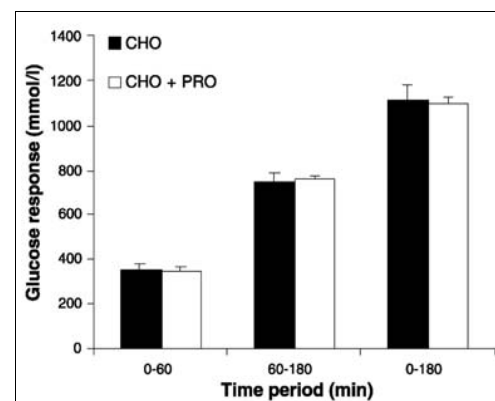


Figure 11. Jentjens et al. JAP 92(2) 839.
Mean muscle glycogen contents and synthesis rates postexercise. No difference was found in the rate of muscle glycogen synthesis between carbohydrate and carbohydrate-protein trials.

Subjects received (a) 1.2 grams carbohydrate per kilogram per hour and 0.4 grams protein per kilogram or (b) 1.2 grams carbohydrate per kilogram per hour.

Muscle biopsies were obtained immediately, 1 hour and 3 hours after exercise.

No differences were found in the rate of muscle glycogen synthesis.

The results of the study are illustrated in Figure 11.

¹⁵ Jentjens, RLP, et al. (2001). Addition of protein and amino acids to carbohydrates does not enhance postexercise muscle glycogen synthesis. *Journal of Applied Physiology*. 91(839).
http://jap.physiology.org/cgi/reprint/91/2/839?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&author1=jentjens&andorexactfulltext=and&searchid=1101345972822_9517&stored_search=&FIRSTIN DEX=0&sortspec=relevance&resourcetype=1. Accessed 11-25-2004.

No Improved Performance with Amino Acids

Burke et al, MSSE, 2003¹⁶

Louise Burke studied amino acids in a carbohydrate sports drink supplement.

The question was whether time trial performance after 2.5 hours of exercise was changed depending upon whether or not protein was added to a carbohydrate drink.

Recovery drinks of 8% carbohydrate and 2% amino acids were compared with 8% carbohydrate alone, and 10% carbohydrate. The 10% carbohydrate solution was calorically equivalent to the 8% / 2% solution.

After 2.5 hours of cycling at 70% of VO₂ max, cyclists performed a 7 kilojoule per kilogram time trial. Eight cyclists received one of the three supplements on each of three different occasions.

In a preliminary abstract report, Burke reported insulin concentrations were the same between trials. There was no difference in fat or carbohydrate oxidation. Time trial performance was the same regardless of treatment.

Summary

Muscles, composed of protein, contain carbohydrate and fat that are used to fuel their action. Some protein may also be broken down during muscle use.

It makes intuitive sense to replace carbohydrate, fat, and protein used during exercise.

The critical questions are how and when.

Stored carbohydrate, glycogen, has been studied for more than half a century.

Restoring glycogen promptly, in the so-called glycogen window, has been shown to improve subsequent performance in those who exercise daily.

Whether protein and fat replacement needs to be as prompt as carbohydrate replacement has not been convincingly shown.

Protein may eventually be shown to help restore or improve muscle structure, but it has not been convincingly shown to help glycogen replacement when carbohydrate intake was adequate or calories consumed were the same for each group.

Fat replacement after exercise may help restore intramuscular lipid.

Even if prompt protein consumption is eventually shown to improve recovery, it is doubtful that this replacement best comes from relatively expensive, advertised, incomplete, and formulated artificial products. Although sports products will be convenient and palatable for some, “real food” is probably better—more complete, balanced, tastier, and less expensive.

During high-intensity exercise, athletes cannot tolerate solid foods. They use sports drinks to replace fluids, electrolytes, and calories. Such sports drinks are convenient and formulated in concentrations generally well-tolerated by the gastrointestinal tract.

After exercise, specialty sports nutritional products are rarely required.

Consider traditional snacks such as sandwiches, fruits, cookies, juices and milk for your immediate after-ride glycogen replacement.

Consider for meals what your parents may have recommended: lots of carbohydrate with moderate amounts of protein and fat. And of course, lots of vegetables.

¹⁶ Burke, L.M., et al. (2003). Addition of amino acids to sports drink does not enhance endurance performance. *Medicine and Science in Sports and Exercise*, 35(5), Supplement abstract 1164. <http://www.ms-se.com/pt/re/msse/fulltext.00005768-200305001-01164.htm;jsessionid=Blq3jqYpUDhL1EHLQ1M3JjKsLf1jT2cPtC1zLU8FBTOYmzXVOB2!-914190194!-949856032!9001!-1?index=11&results=1&count=10&searchid=10&nav=search>. Accessed 11-24-2004.

Fats: Types, Structure

This section is somewhat technical. If you do not have a scientific bent, you may prefer to skip on to *Dietary Fat* on page 77.

Fats or Lipids

The term lipids includes many compounds: triglycerides, mono- and diglycerides, phosphatides, cerebrosides, sterols, terpenes, fatty alcohols, fatty acids, fat-soluble vitamins, and other substances.

Triglycerides

At normal room temperatures, triglycerides range in consistency from solids to liquids. When solid they are referred to as “fats” and when liquid they are called “oils.”

Fatty acids are rarely found unattached in the body.

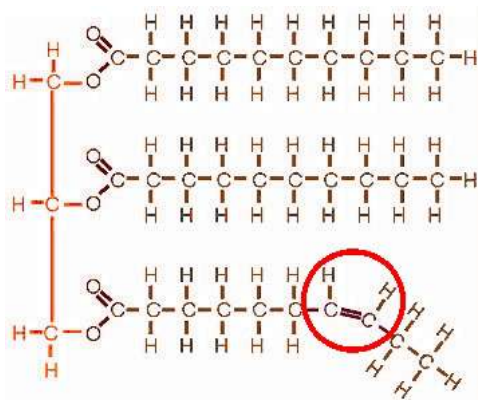


Figure 12. Triglyceride structure. Three fatty acids attached to a RED glycerol backbone. The RED circle outlines a *cis*-unsaturated double bond. Cis- and trans-double bonds are discussed on page 76.

Most of the fats we eat are triglycerides—three fatty acids attached to a glycerol molecule.

The glycerol holds the three fatty acids. It is a relatively small part of the fat molecule. One hundred grams of fat or oil will yield about 95 grams of fatty acids and 5 grams of glycerol.

The physical and chemical characteristics of fats are influenced by the kinds and proportions of the component fatty acids and the way in which these are positioned on the glycerol molecule.

Fatty Acids

Fatty acids are linear hydrocarbon chains containing from 4 to 30 hydrocarbons, most commonly 12 to 24 carbons.

One end of the molecule contains a carboxylic acid group from which chemists count the number of carbons. The other end is the methyl, “n,” or omega end from which nutritionists and biochemists count the position of the first double bond in unsaturated fats.

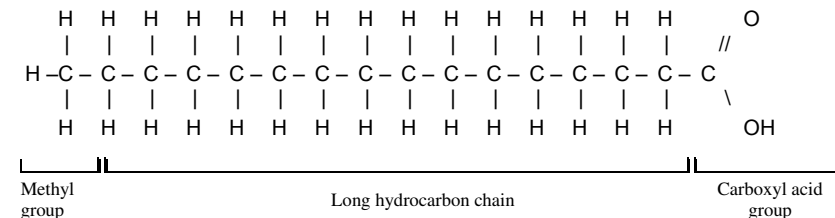


Figure 13. Chemical features of a fatty acid. This is the saturated palmitic acid.

Saturated Fats

An octopus has eight arms. Think of a tetrapus carbon as having four arms. In fats, these four arms hold on to other carbons, hydrogen, or oxygen.

When all the carbons in a fatty acid hold on to other carbons with just one arm, using their other arms to hold onto hydrogens, fatty acids are termed saturated. These exist as straight chains.

Saturated fatty acids are the least reactive chemically.

The melting point of saturated fatty acids increases with chain length. Decanoic and longer chain fatty acids are solids at normal room temperatures.

The most common saturated fatty acid in nature is palmitic acid, a 16-carbon fatty acid.

Saturated fatty acids, common name, carbon chain length, melting point, and typical source are listed in Table 10.

Systematic Name	Common Name	Carbon Atoms	Melting Point ° C	Typical Fat Source
Butanoic	Butyric	4	-7.9	Butterfat
Hexanoic	Caproic	6	-3.4	Butterfat
Octanoic	Caprylic	8	16.7	Coconut oil
Decanoic	Capric	10	31.6	Coconut oil
Dodecanoic	Lauric	12	44.2	Coconut oil
Tetradecanoic	Myristic	14	54.4	Butterfat, coconut oil
Hexadecanoic	Palmitic	16	62.9	Most fats and oils
Octadecanoic	Stearic	18	69.6	Most fats and oils
Eicosanoic	Arachidic	20	75.4	Peanut oil
Docosanoic	Behenic	22	80.0	Peanut oil

Table 10. Saturated fatty acids.

Unsaturated Fatty Acids

When carbon atoms hold on to each other extra tightly with two arms, rather than to hydrogen atoms, fats are unsaturated.

When two hydrogen atoms are removed from the chain, a carbon-to-carbon double bond or point of unsaturation is created and the molecule bends.

Fatty acids containing one or more carbon-to-carbon double bonds are unsaturated.

Systematic Name	Common Name	Double Bonds	Carbon Atoms	Typical Fat Source
9-Decenoic	Caproic	1	10	Butterfat
9-Dodecenoic	Lauroic	1	12	Butterfat
9-Tetradecenoic	Myristoleic	1	14	Butterfat
9-Hexadecenoic	Palmitoleic	1	16	Fish oils, beef fat
9-Octadecenoic	Oleic	1	18	Fats and oils
9-Octadecenoic	Elaidic	1	18	Hydrogenated oils
11-Octadecenoic	Vaccenic	1	18	Butterfat
9,12-Octadecadienoic	Linoleic	2	18	Vegetable oils
9,12,15-Octadecatrienoic	Linolenic	3	18	Soybean oil, canola oil
9-Eicosaenoic	Gadoleic	1	20	Fish oils
5,8,11,14-Eicosatetraenoic	Arachidonic	4	20	Lard
5,8,11,14,17-Eicosapentaenoic	-	5	20	Fish oils
13-Docosenoic	Erucic	1	22	Canola oil
4,7,10,13,16, 19-Docosahexaenoic		6	22	Fish oils

Table 11. Unsaturated fatty acids in food fats and oils. In many sources, saturated fats are also present.

If a fatty acid contains one double bond, it is monounsaturated. If it contains more than one double bond, it is polyunsaturated.

Unsaturated fatty acids are more reactive chemically than are saturated fatty acids. This reactivity increases as the number of double bonds increases.

In general, the more saturated the fat, the more likely it is to be solid at room temperature—and the more dangerous it is for health.

Oleic acid is the monounsaturated fatty acid that occurs most frequently in nature.

Of the polyunsaturated fatty acids, linoleic, linolenic, arachidonic, eicosapentaenoic, and docosahexaenoic acids containing respectively two, three, four, five, and six double bonds are of the most nutritional interest.

Unsaturated fatty acids, common name, number double bonds, carbon chain length, and typical source are listed in Table 11.

Naming

Omega, N-Minus System

In the omega or “n-minus” system, the first number is the length of the fatty acid chain; the second number, after a colon, is the number of double bonds.

A third number, after, “n minus,” indicates the position of the first double bond counting from the methyl or omega end of the molecule.

The most common are the omega-3 and omega-6 fatty acids.

Location of the first double bond end determines whether the fatty acid is an omega-3 or omega-6 fatty acid.

For example, linoleic acid is 18:2n-6. Linoleic acid is an 18-carbon omega-6 fatty acid with two double bonds. It is abundant in plants and in vegetable and seed oils.

Alpha-linolenic acid is 18:3n-3. Alpha-linolenic acid is an 18-carbon omega-3 fatty acid with three double bonds. It is found in plants and oils.

Eicosapentaenoic acid, found in many fish oils, is an omega-3 fatty acid.

Oleic acid, which has its double bond 9 carbons from the methyl end, is considered an omega-9 (or an n-9) fatty acid.

IUPACE System

In the International Union of Pure and Applied Chemistry (IUPAC) system of nomenclature, the carbons in a fatty acid chain are numbered consecutively from the end of the chain, the carbon of the carboxyl group being considered as number 1.

By convention, a specific bond in a chain is identified by the lower number of the two carbons that it joins. In oleic acid (*cis*-9-octadecenoic acid), for example, the double bond is between the ninth and tenth carbon atoms.

When two fatty acids are identical except for the position of the double bond, they are referred to as positional isomers. Fatty acid isomers are discussed next.

Long-Chain Polyunsaturated Fatty Acids

These are fatty acids with 20 or more carbon atoms.

Long-chain polyunsaturated fatty acids of the omega-6 family are arachidonic acid (20:4n-6) and docosapentaenoic acid (22:5n-6).

Long-chain polyunsaturated fatty acids of the omega-3 family are eicosapentaenoic acid (20:5n-3) and docosahexaenoic acid (22:6n-3).

Trans Fat

Trans fat is made when hydrogen is added to vegetable oil—a process called hydrogenation.

Hydrogenation turns an unsaturated fat into a polyunsaturated fat containing trans-fatty acids.

In nature, the hydrogen atoms at a double bond are usually positioned on the same side of the carbon chain. This type of configuration is called *cis* (*on this side* in Latin).

Partial hydrogenation reconfigures some double bonds and the hydrogen atoms end up on different sides of the chain. This type of configuration is called *trans* (*across* in Latin).

The structure of a saturated, an unsaturated, and a *trans* unsaturated chemical bond is depicted in Table 12 and in Figure 14.

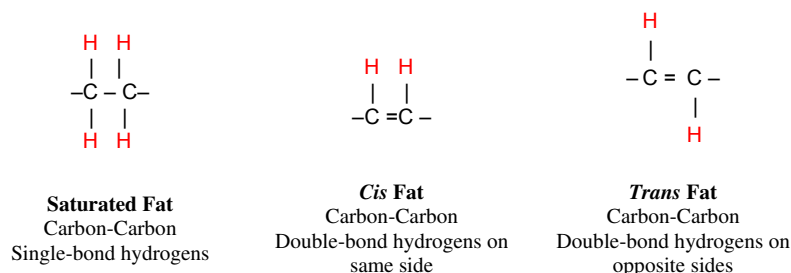


Table 12. Depiction of saturated, *cis*-unsaturated, and *trans*-unsaturated fats. RED hydrogens are on the same side of a *cis*-double bond and on the opposite sides of a *trans*-double bond.

Cis-fats are bent. This bending causes the molecule to occupy more space and become more fluid. This is illustrated in Figure 14.

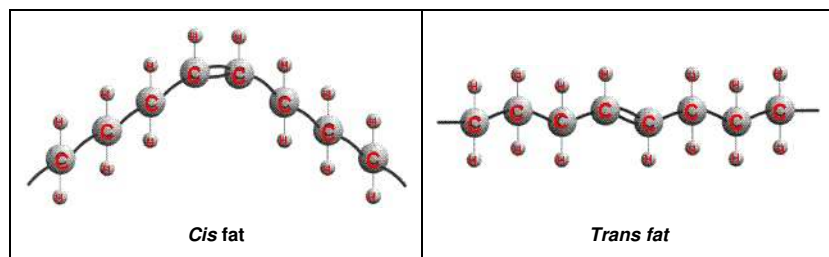


Figure 14. *Cis* fats are bent. *Trans* fats are generally straight.

Dietary Fat

Fat tastes good to most of us—it makes carbohydrate more palatable. Fat is also relatively inexpensive.

A small amount of fat is necessary in the diet.

Diets that derive more than 30% of their calories from fat are considered unhealthy, because excess dietary fat is associated with obesity, heart disease, stroke, and some cancers.

Polyunsaturated fats are believed to be better for health than saturated or hydrogenated fats. Diets that derive more than 10% of their calories from saturated fat are considered unhealthy.

US fat consumption averages about 33% of total calories.

Excess fat is much more of a public health problem than too little.

Requirements

Dietary fat is composed of triglycerides, phospholipids, sterols, and other lipid-soluble components.

Triglycerides are the major component of dietary fats.

Triglycerides consist of a glycerol backbone and three fatty acid chains, the latter of which are classified as saturated, *cis*-monounsaturated, *cis*-polyunsaturated, and *trans*-fatty acids.

Monounsaturated fatty acids, saturated fatty acids, and cholesterol can be synthesized by the body. They are not essential in the diet.

Two polyunsaturated fatty acids are essential in the diet: linoleic acid and alpha-linolenic acid.

Eicosapentaenoic acid and docosahexaenoic acid, two fatty acids derived from the elongation and desaturation of alpha-linolenic acid, are also of nutritional significance. Eicosapentaenoic acid and docosahexaenoic acid can be interconverted.

For more information on the different kinds of fats and their chemical structure, see page 74.

Total Fat

There is no US Food and Nutrition Board (FNB) recommendation for RDA or AI (adequate intake) for total fat.

The optimal intake is not known. There is insufficient data to define a level of fat intake at which risk of inadequacy or prevention of chronic disease occurs.

The FNB has established an Acceptable Macronutrient Distribution Range (AMDR).

This is the range of intake for a particular energy source that is associated with reduced risk of chronic disease while providing intakes of essential nutrients. Consumption in excess of the AMDR is associated with chronic disease. Insufficient intake risks missing essential nutrients.

The AMDR for total fat is 20% to 35% of caloric intake.

Carbohydrate and protein not needed for other functions are converted to and stored as body fat.

Essential Fatty Acids: Adequate Intake (AI)

The adult (aged 19-50 years) daily AI for linoleic acid is 17 grams for men and 12 grams for women.

The adult daily AI for alpha-linolenic acid is 1.6 grams for men and 1.1 grams for women.

The FNB adequate intakes for linoleic acid and alpha-linolenic acid are based on US median intakes. Omega-6 and omega-3 fatty acid deficiencies are almost non-existent in healthy individuals.

The AMDR for linoleic acid is 5% to 10% of total energy intake while that for alpha-linolenic acid is 0.6% to 1.2% of total energy intake.

The lower boundaries of these ranges are based on the amounts needed to meet the AI for adults and children for these nutrients.

The upper boundary for linoleic acid was set based on: the highest daily US intakes of omega-6 polyunsaturated fatty; the general lack of evidence demonstrating the safety of long-term intakes greater than 10% of energy; and evidence demonstrating that high intakes of linoleic acid create a pro-oxidant state that may predispose individuals to chronic diseases.

The upper boundary for alpha-linolenic acid corresponds to the highest daily US intakes of this fatty acid.

Consumption of eicosapentaenoic acid and docosahexaenoic acid at moderate levels may provide beneficial health effects. Up to 10% of the AMDR for alpha-linolenic acid can be consumed as eicosapentaenoic acid and/or docosahexaenoic acid.

Tolerable Upper Intake Level (UL)

No tolerable upper level of intake has been established.

Heart-healthy percentage intakes of fat types are established. For information, see *Heart-Healthy Fat* on page 87.

Minimal Fat Intake

Eating the recommended number of servings from each of the major food groups (milk, vegetable, meat, fruit, and bread) results in a diet with about 15% of total calories from fat—even with low-fat foods and no added fat or oil during preparation.

A single tablespoon of corn oil is enough to meet the daily physiological requirement for fat. The average American consumes eight times this amount of fat—the equivalent of a stick of butter.

Sources

Both animal and plant-derived food products contain fat.

The principal sources are meats, dairy products, poultry, fish, nuts, and vegetable fats and oils.

Most vegetables and fruits consumed as such contain only small amounts of fat.

Saturated Fats

Often solid at room temperature, saturated fats are high in well-marbled meats and whole-milk dairy products.

High amounts of saturated fat are found in beef, pork, lamb, chicken skin, butter, whole milk, and cheese.

Some vegetable fats are also saturated; for example, palm kernel and coconut oils.

Polyunsaturated Fats

Vegetable oils are the principal sources of linoleic and alpha-linolenic acids. Arachidonic acid is found in small amounts in lard, which also contains about 10% of linoleic acid. Fish oils contain large quantities of a variety of longer chain fatty acids having three or more double bonds including eicosapentaenoic and docosahexaenoic acids.

Trans (Hydrogenated) Fats

A small amount of *trans* fat is found naturally in animal-based foods. Most *trans* fat is a specific type of fat formed when liquid oils are made into solid fats like shortening and hard margarine.

Food manufacturers solidify unsaturated liquid fats through a process called hydrogenation. This is used to create margarine or shortening for use in deep-fat frying or as an ingredient in baked goods, snack foods, crackers, and candy. Hydrogenation increases the shelf life and flavor stability of foods containing these fats.

The FDA estimates the average adult US daily intake of *trans* fat is 5.8 grams or 2.6% of calories.

On average, Americans consume 4 to 5 times as much saturated fat as *trans* fat in their diet.

Heart-Healthy Fat

For more information about saturated, unsaturated, and *trans* fats, see *Heart-Healthy Fat* on page 87.

Function, General

Dietary fat is a major source of energy. Fat provides about two-thirds of the energy muscles require. It provides the most concentrated source of energy of any foodstuff, 9 calories per gram.

Fat is required for the absorption of fat-soluble vitamins (vitamins A, D, E, and K) and carotenoids.

As a food ingredient, fat provides taste, consistency, and stability and helps us feel full.

Fat is important for proper growth, development, and maintenance of good health.

Fat maintains healthy skin and hair, cushions the bones and vital organs, and protects the body from cold temperature.

Energy

More than 80% of alpha-linolenic acid and much linoleic acid are consumed in energy production.

Essential Fatty Acids

By definition, essential fatty acids cannot be synthesized in the body and are required for health.

The main biological roles of essential fatty acids are as regulators of gene expression; as structural components of cell membranes, particularly in nerve tissue and in the retina; and as precursors of eicosanoids.

Linoleic Acid

Linoleic acid is essential as a precursor of arachidonic acid, a substance required for the production of eicosanoids. Read more about eicosanoids on the next page.

Linoleic acid deficiency is associated with growth deficiencies and skin problems.

Linoleic acid is widespread in plants and seed oils; arachidonic acid is found mainly in meats, egg yolk, and some fish.

Alpha-Linolenic Acid

The only known function of alpha-linolenic acid is to serve as a precursor for the synthesis of the long-chain omega-3 fatty acids, eicosapentaenoic acid and docosahexaenoic acid.

For detailed information, see *Omega-3 Fatty Acids* on page 81.

Docosahexaenoic Acid

Docosahexaenoic acid is a conditionally essential nutrient. Its production from alpha-linolenic acid may be inadequate to meet needs for brain growth in early human development and it confers functional benefit even when alpha-linolenic acid is in the diet.

Both docosahexaenoic acid and arachidonic acid are available in breast milk and in many infant formulas.

For detailed information, see *Omega-3 Fatty Acids* on page 81.

Long-Chain Polyunsaturated Fatty Acids

Long-chain polyunsaturated acids have several roles:

- Oxidation to provide energy
- Triglyceride synthesis and limited tissue storage
- Phospholipids in membranes, particularly neural tissue
- Eicosanoid synthesis: prostaglandins, thromboxanes, leukotrienes

Membranes

As structural components of membranes, arachidonic acid and docosahexaenoic acid influence the functional characteristics of tissues, particularly neural tissues.

Docosahexaenoic acid is concentrated in the outer segment of the rods in the retina of the eye. The presence of docosahexaenoic acid is related to light activation and visual processing.

For detailed information, see *Omega-3 Fatty Acids* on page 81.

Eicosanoids

Arachidonic acid is the major precursor for the synthesis of eicosanoids, cellular regulatory substances and mediators of inflammation that include prostaglandins, thromboxanes, and leukotrienes.

Eicosanoids are involved in platelet aggregation, T-cell proliferation, lymphocyte migration, vasoconstriction and dilation, and the production of several immune and inflammatory substances.

In the presence of eicosapentaenoic acid, eicosanoids derived from the omega-3 family are also produced. These attenuate or inhibit the action of the arachidonic acid -derived eicosanoids. Those derived from eicosapentaenoic acid have weaker biological activity than those from arachidonic acid.

Competition from omega-3 fatty acids for the same eicosanoid synthesizing enzymes may reduce the production of omega-6 eicosanoids.

Eicosapentaenoic acid can moderate the production and activity of arachidonic acid-derived eicosanoids.

The predominance of eicosanoids derived from omega-6 fatty acids may contribute to chronic diseases, including heart disease.

For detailed information, see *Omega-3 Fatty Acids* on page 81.

Toxicity

Cardiovascular Diseases

See *Heart-Healthy Fat* on page 87.

Cancer

The link between fat intake and cancer is controversial.

Although a study by the Harvard Medical School found no relationship between fat intake and breast cancer, the disease occurs more frequently in countries where women have high average intakes of both total fat and saturated fat. (American women are six times more likely to develop breast cancer than Japanese women, who eat far less fat.)

Studies are mixed as to whether a high-fat diet increases the risk of cancer of the colon, ovary, uterus, endometrium, and prostate.

Athletic Considerations

Fat (especially) and protein slow the workings of the stomach and intestines in comparison with carbohydrate. Fatty meals before intense efforts are associated with stomach bloating and gastrointestinal distress.

Slow long-distance cycling burns mostly fat. Higher-intensity efforts require not only fat but also the higher levels of energy provided by carbohydrate.

By analogy, one might say that high-glycemic carbohydrates are like burning paper, medium- and low-glycemic carbohydrates are like burning wood, and fats are like burning coal.

Medium-chain triglycerides (MCTs)—partially broken down fats—were reported by Van Zyl in 1996 to improve performance. Promotion and marketing of these products quickly followed. Efforts to reproduce these results failed.

For more information about overall macronutrient mix recommendations for aerobic endurance athletes, see page 47.

Omega-3 Fatty Acids

Omega-3 fatty acids are polyunsaturated, meaning they contain more than one double bond. They are called omega-3 fatty acids because the first double bond from the methyl end is located at the third carbon atom.

Alpha-linolenic acid is an essential omega-3 fatty acid.

Humans can synthesize other needed omega-3 fatty acids from alpha-linolenic acid, including eicosapentaenoic acid and docosahexaenoic acid.

Eicosapentaenoic acid and docosahexaenoic acid are abundant in some fish; they are referred to as marine-derived omega-3 fatty acids. Alpha-linolenic acid is a plant-derived omega-3 fatty acid.

Linoleic acid is another essential polyunsaturated fatty acid; it is an omega-6 fatty acid and has two double bonds.

It has been estimated that the ratio of omega-6 to omega-3 fatty acids in the diet of early humans was 1:1. The ratio in the typical US diet is about 10:1 due to increased use of vegetable oils rich in linoleic acid and declining fish consumption.

Increasing the relative amount of dietary omega-3 fatty acids may have health benefits.

Requirements: Adequate Intake (AI)

The 2002 US Food and Nutrition Board (FNB) daily adult adequate dietary intake levels (AIs) for omega-3 fatty acids is 1.6 grams of alpha-linolenic acid for men and 1.1 grams of alpha-linolenic acid for women.

Sources

Nutrient

Alpha-Linolenic Acid

Alpha-linolenic acid is found in plants, particularly flax seed and oil, canola and soybean oils, and English walnuts. It is also abundant in perilla seeds and oils and in purslane, a vegetable used in the Middle East.

The average daily adult intake of alpha-linolenic acid is about 1.4 grams for men and about 1.0 grams for women, just below the FNB recommended AIs.

Alpha-linolenic acid content of selected foods is listed in Table 13.

Food	Serving	Alpha-Linolenic acid, g
Flaxseed oil	1 tablespoon	8.5
Walnuts, English	1 ounce	2.6
Flaxseeds	1 tablespoon	2.2
Walnut oil	1 tablespoon	1.4
Canola oil	1 tablespoon	1.2
Mustard oil	1 tablespoon	0.8
Soybean oil	1 tablespoon	0.9
Walnuts, Black	1 ounce	0.6
Olive oil	1 tablespoon	0.1
Broccoli, raw	1 cup, chopped	0.1

Table 13. Alpha-linolenic acid content of selected foods.

Eicosapentaenoic Acid, Docosahexaenoic Acid

Fish oils and fatty fish are major dietary sources of eicosapentaenoic acid and docosahexaenoic acid.

Fatty fish include salmon, rainbow trout, sardines, and mackerel.

The average daily adult intake of eicosapentaenoic acid is about 0.05 grams per day. The average daily adult intake of docosahexaenoic acid is about 0.07 grams per day.

Omega-3 fatty acid-enriched eggs are available.

One such egg produced by adding flaxseed to hens' feed is reported to contain 0.25 g of eicosapentaenoic acid and 0.15 g of docosahexaenoic acid.

Eicosapentaenoic acid and docosahexaenoic acid content of selected foods is listed in Table 14.

Food	Serving	EPA, g	DHA, g
Cod, Pacific, cooked	3 ounces	0.09	0.15
Crab, Dungeness, cooked	3 ounces	0.24	0.10
Herring, Pacific, cooked	3 ounces	1.06	0.75
Oysters, Pacific, cooked	3 ounces	0.75	0.43
Salmon, Atlantic, cooked	3 ounces	0.28	0.95
Salmon, Chinook, cooked	3 ounces	0.86	0.62
Salmon, sockeye, cooked	3 ounces	0.45	0.60
Sardines, packed in oil	3 ounces	0.77	0.65
Shrimp, cooked	3 ounces	0.15	0.12
Trout, rainbow, cooked	3 ounces	0.40	0.44
Tuna, white, packed in water	3 ounces	0.20	0.54
Fish oil, menhaden	1 gram	0.13	0.09
Fish oil, salmon	1 gram	0.13	0.18

Table 14. Eicosapentaenoic acid and docosahexaenoic acid content of selected foods.

Synthesis of Eicosapentaenoic and Docosahexaenoic Acids

Humans can synthesize eicosapentaenoic acid and docosahexaenoic acid from alpha-linolenic acid.

In men, about 8% of dietary alpha-linolenic acid is converted to eicosapentaenoic acid and up to 4% is converted to docosahexaenoic acid.

In women, about 21% of dietary alpha-linolenic acid is converted to eicosapentaenoic acid and 9% is converted to docosahexaenoic acid.

Variations in dietary omega-6 and long-chain omega-3 eicosapentaenoic acid levels may affect the efficiency of alpha-

linolenic acid conversion to eicosapentaenoic acid and docosahexaenoic acid.

Supplements

Flaxseed oil is available as an alpha-linolenic acid supplement.

A number of fish oils are marketed as omega-3 fatty acid supplements.

Ethyl esters of eicosapentaenoic acid and docosahexaenoic acid are concentrated sources of marine-derived omega-3 fatty acids.

Docosahexaenoic acid supplements derived from algae are also available.

Omega-3 fatty acid supplements are absorbed more efficiently with meals. Dividing one's daily dose into two or three smaller doses throughout the day decrease gastrointestinal side effects.

Although cod liver oil is a rich source of eicosapentaenoic acid and docosahexaenoic acid, it also contains potentially toxic levels of vitamin A and vitamin D.

Infant Formula

US infant formula manufacturers market products with docosahexaenoic acid and arachidonic acid added.

Manufacturers are not required to list the amounts on the label.

Interactions

Interactions are listed in the footnote.¹⁷

¹⁷ **Interactions**

Nutrient

Linoleic Acid

Alpha-linolenic acid and linoleic acid compete for the same enzymes.

The interaction is probably most important in those who have low eicosapentaenoic acid and docosahexaenoic acid intakes.

Eicosapentaenoic acid accumulates in brain and retinal membranes when docosahexaenoic acid is inadequate, as happens in alpha-linolenic acid deficiency.

Vitamin E

Limited data suggests that the amount of vitamin E required to prevent lipid peroxidation increases with the amount of polyunsaturated fat consumed.

Drug

Flaxseed Oil (Alpha-Linolenic Acid).

May decrease clotting. Use with caution in those on anticoagulant medications.

Function

Alpha-Linolenic Acid

The only known function of alpha-linolenic acid is to serve as a precursor for the synthesis of the long-chain omega-3 fatty acids, eicosapentaenoic acid and docosahexaenoic acid.

Eicosapentaenoic Acid

Eicosanoids are chemical messengers derived from 20-carbon polyunsaturated fatty acids. They play roles in immune and inflammatory responses.

In general, eicosanoids derived from eicosapentaenoic acid are less potent inducers of inflammation, blood vessel constriction, and clotting than eicosanoids derived from arachidonic acid.

Docosahexaenoic Acid

Vision

Docosahexaenoic acid plays a role in the regeneration of the visual pigment rhodopsin, which plays a critical role in the visual transduction system that converts light to vision.

Nervous System Function

Docosahexaenoic acid is thought to be important to neurologic function; the mechanisms of action are uncertain.

Omega-3 Fatty Acids

Regulation of Gene Expression

Omega-3 fatty acids may regulate gene expression through their effects on the activity of transcription factors.

Eicosapentaenoic Acid and Docosahexaenoic acid

Anticoagulants. Fish oil or marine-derived omega-3 fatty acid may interact, increasing anticoagulant effects.

Mixed studies.

Antihypertensive agents. May increase antihypertensive effects.

Deficiency

Deficiency is rare. Cases provide evidence of the essentiality of omega-3 fatty acids.

A young girl receiving intravenous lipid emulsions with little alpha-linolenic acid developed visual problems and sensory neuropathy. These resolved with an emulsion containing more alpha-linolenic acid

Scaly and hemorrhagic skin and scalp inflammations, impaired wound healing and growth retardation were described in a series of nine nursing home patients fed by gastric tube for years with a diet formula with little alpha-linolenic acid.

Disease Prevention

Visual and Neural Development

Preterm Infants

Human milk contains docosahexaenoic acid in addition to alpha-linolenic acid and EPA. Human milk is considered the best source of omega-3 fatty acids for infants.

Adding docosahexaenoic acid to the formula of preterm infants improves the early development of the visual system.

Term Infants

The benefits of adding docosahexaenoic acid to the formula of term infants are less clear than those seen in preterm infants.

Studies on visual acuity are mixed.

Pregnancy Complications

Omega-3 fatty acid supplements do not decrease pregnancy-induced hypertension. It may result in modest increases in length of pregnancy, especially in women with low omega-3 fatty acid consumption.

Cardiovascular Diseases

Fish and Coronary Heart Disease

Some studies, but not all, have shown that those who eat fish at least once weekly have lower mortality from coronary heart disease than those who do not eat fish.

Alpha-Linolenic Acid and Coronary Heart Disease

There is some evidence that increased alpha-linolenic acid intake is associated with decreased risk of MI and fatal coronary heart disease. Studies are mixed.

Fish and Sudden Cardiac Death

Several studies have found an inverse relationship between fish consumption and sudden cardiac death.

Fish and Stroke

Studies are mixed.

Increased fish intake may decrease the risk of thrombotic or ischemic stroke but not hemorrhagic stroke.

Cancer

Numerous studies have examined dietary fish intake and cancer incidence; few have shown inverse relationships between fish or omega-3 fatty acid intake and the risk of breast, prostate, or colorectal cancer.

Disease Treatment

Coronary Heart Disease

Studies suggest a beneficial effect of dietary and supplemental omega-3 fatty acids.

The American Heart Association recommends that those with documented coronary heart disease consume 1 gram daily of eicosapentaenoic acid and docosahexaenoic acid combined (EPA + DHA).

To read the statement, see:
<http://circ.ahajournals.org/cgi/content/full/106/21/2747>.

Diabetes

Cardiovascular diseases are the leading causes of death in diabetics.

Hypertriglyceridemia is a common lipid abnormality in diabetics.

Fish oil supplementation significantly lowers serum triglyceride levels in diabetics.

Increasing eicosapentaenoic acid and docosahexaenoic acid intakes may be beneficial to diabetic individuals especially those with elevated serum triglycerides.

There is little evidence that combined daily eicosapentaenoic acid and docosahexaenoic acid intakes of less than 3 grams per day adversely affect long-term glycemic control in diabetics.

Inflammatory Diseases

Rheumatoid Arthritis

Supplements with fish oil may help rheumatoid arthritis.

Inflammatory Bowel Disease

Omega-3 fatty acid supplements have not usually helped those with inflammatory bowel disease.

Asthma

Marine-derived omega-3 fatty acid supplementation in asthmatic patients has not been shown to be helpful.

Immunoglobulin A Nephropathy

Studies have not shown that fish oil supplements prevent the progression of IgA nephropathy in children or adults.

Major Depression and Bipolar Disorder

There are no controlled studies on the efficacy of omega-3 fatty acid supplementation in patients with depression.

Schizophrenia

Results of randomized controlled trials using ethyl-eicosapentaenoic acid are mixed.

Toxicity

Flax Seed Oil (Alpha-Linolenic Acid)

May cause loose stools or diarrhea. Allergic reactions have been reported.

Eicosapentaenoic and Docosahexaenoic Acids

May cause a fishy aftertaste. Belching and heartburn have been reported. High doses may cause nausea and loose stools.

Bleeding

The potential for high omega-3 fatty acid intakes to prolong bleeding times may play a role in their cardioprotective effects.

The FDA has ruled that intakes up to 3 grams per day of marine-derived omega-3 fatty acids are Generally Recognized As Safe (GRAS) for inclusion in the diet.

The FNB has not established a tolerable upper level of intake (UL) for omega-3 fatty acids. Caution is advised with the use of supplemental eicosapentaenoic acid and docosahexaenoic acid, especially in those taking anticoagulants or otherwise at increased risk of excessive bleeding.

Immune System Suppression

The suppression of inflammatory responses from omega-3 fatty acid intakes may benefit individuals with inflammatory or autoimmune diseases; anti-inflammatory doses may decrease the ability of the immune system to destroy pathogens.

Contaminants

Fish

Some species of fish may contain significant levels of methylmercury, polychlorinated biphenyls (PCBs), or other environmental contaminants.

In general, older, larger, predatory fish, including swordfish, tend to contain the highest levels of these contaminants.

Removing the skin, fat, and internal organs of the fish prior to cooking, and allowing the fat to drain from the fish while it cooks will decrease exposure to a number of fat-soluble pollutants, including PCBs.

However, methylmercury is found throughout the muscle of fish, so these cooking precautions will not reduce exposure to methylmercury.

Methylmercury

Organic mercury compounds are toxic and excessive exposure can cause brain and kidney damage.

Unborn children, infants, and young children are especially vulnerable to the toxic effects of mercury on the brain.

The FDA recommends women who may become pregnant, pregnant and breastfeeding women, and young children:

1. Do not eat shark, swordfish, or king mackerel; they contain levels near 1 part per million.
2. Limit the consumption of other fish to 12 ounces per week.

Read the advisory at:

<http://www.fda.gov/oc/opacom/mehgadvisory1208.html>.

For others, the FDA recommends eating no more than 7 ounces per week of fish with methylmercury levels near 1 part per million and no more than 14 ounces per week of fish with levels averaging 0.5 part per million.

Typical methylmercury levels in fish are outlined in Table 15.

Fish	Methylmercury (ppm)
Swordfish	1.00
Shark	0.96
King Mackerel	0.73
Red Snapper	0.60
Orange Roughly	0.58
Bass, Saltwater	0.49
Marlin	0.47
Tuna (fresh or frozen)	0.32
Lobster Northern (American)	0.31
Halibut	0.23
Crab Dungeness	0.18
Tuna (canned)	0.17

Table 15. Typical methylmercury levels in fish, in parts per million.

Supplements

Methylmercury. Supplements available in the US probably contain less than 1.5 parts per billion.

Polychlorinated biphenyls (PCBs). Fish oil supplements in the US probably do not have appreciable PCBs or dioxin.

Summary

Alpha-linolenic acid (an omega-3 fatty acid) and linoleic acid (an omega-6 fatty acid) are both essential fatty acids.

The marine-derived omega-3 fatty acids, eicosapentaenoic acid and docosahexaenoic acid, can be synthesized from alpha-linolenic acid or obtained in the diet.

US diets tend to be higher in omega-6 fatty acids than omega-3 fatty acids.

Increased dietary marine-derived omega-3 fatty acid intakes are associated with decreased risks of cardiovascular diseases.

The American Heart Association recommends that all adults eat fish, particularly fatty fish, at least twice weekly.

The American Heart Association recommends that those with documented coronary heart disease consume 1 gram per day of eicosapentaenoic acid and docosahexaenoic acid combined.

Eicosapentaenoic acid and docosahexaenoic acid may be helpful to diabetics. There is little evidence that intakes of less than 3 grams per day have side effects.

Heart-Healthy Fat

Fat Key Points

- Keep total fat intake less than 30% of daily calories.
There are 9 calories in a gram of fat.
The maximum fat allowance in a 2,100-calorie diet is 70 grams a day.
- Dietary fat should be mostly mono- and polyunsaturated fatty acids
- Polyunsaturated fatty acids provide essential fatty acids (linoleic and alpha-linolenic acid).
- Keep saturated and *trans* fat less than 10% of daily calories.
- Keep cholesterol intake less than 300 milligrams daily.
- High blood levels of LDL and total cholesterol are dangerous.
- High levels of HDL cholesterol are desirable.
- Exercise regularly to raise HDL levels.

For a discussion of fat names and chemistry, see *Fats: Types, Structure* on page 74.

For more information about cholesterol, including LDL and HDL cholesterol, see the free supplement to this book available through at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Overall Fat Allowance

Total adult fat intake is heart-healthy between 20% and 30% of total energy intake.

This range allows for sufficient intakes of essential nutrients while keeping the intake of saturated fatty acids at moderate levels.

The maximum daily heart-healthy recommendation is to get no more than 30% of calories from fat.

Each gram of fat supplies 9 calories.

Therefore, multiply total daily calories by 30% and divide by 9 to determine your maximum daily fat allowance in grams.

For example, suppose your total daily intake is 2,100 calories. Multiply by 30% to get 630 calories from fat. Divide by 9 to get 70 grams of fat, your maximum daily fat allowance.

For a diet targeting 20% of calories from fat, multiply total daily calories by 20% and divide by 9 to get your daily fat allowance in grams.

For example, suppose your total daily intake is 2,100 calories. Multiply by 20% to get 420 calories from fat. Divide by 9 to get 47 grams of fat, your daily fat allowance.

For a quick reference to fat allowances for other daily caloric intakes, see Table 16.

Total Daily Calories Percent from Fat	Fat Allowance Calories		Fat Allowance Grams	
	30%	20%	30%	20%
1500	450	300	50	33
1600	480	320	53	36
1700	510	340	57	38
1800	540	360	60	40
1900	570	380	63	42
2000	600	400	67	44
2100	630	420	70	47
2200	660	440	73	49
2300	690	460	77	51
2400	720	480	80	53
2500	750	500	83	56
2600	780	520	87	58
2700	810	540	90	60
2800	840	560	93	62
2900	870	580	97	64
3000	900	600	100	67

Table 16. Caloric and grams fat allowance based on daily calories.

Controlling Weight

Total energy intake is the key factor in regards to weight control regardless of the proportion of protein, fat and carbohydrate in the diet.

Fat is calorically dense. Fats make foods calorically dense. A 4-ounce portion of oil has about 1,000 calories, but 4 ounces of carrots, celery, apples, or lettuce have less than 50 calories.

Higher-fat diets are moderately hypercaloric when compared with diets containing less fat. At isocaloric intakes, low-fat diets do not produce weight loss.

Read about body fat, obesity, and tips to lose weight in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Saturated Fatty Acids, *Trans* Fatty Acids, Cholesterol

Intakes of saturated fatty acids, *trans* fatty acids and cholesterol have each been independently and positively associated with lipid biomarkers of heart disease including LDL-cholesterol.

Excess intake of these types of fat increases the risk of coronary heart disease.

It is neither possible nor desirable to achieve zero percent of energy from saturated fatty acids or *trans* fatty acids. Some intake of these fats is necessary to have an otherwise balanced diet.

Aim to keep saturated and *trans* fatty acid daily intake less than 10% of total calories. Many Americans consume two to three times as much saturated fat as recommended.

Total fat, saturated fat, and trans fat content of selected foods is given in Table 17.

Cholesterol is discussed in more detail in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Product	Serving	Total Fat, g	Sat. Fat, g	Trans Fat, g	Combined Sat. & Trans Fat g
Butter	1 tbsp	11	7	0	7
Cake, pound	80 g	16	3.5	4.5	8
Candy Bar	1, 40 g	10	4	3	7
Doughnut	1	18	4.5	5	9.5
French Fries	Med, 150 g	27	7	8	15
Margarine, stick	1 tbsp	11	2	3	5
Margarine, tub	1 tbsp	7	1	0.5	1.5
Mayonnaise, soy	1 tbsp	11	1.5	0	1.5
Milk, fat-free	8 ounces	0	0	0	0
Milk, whole	8 ounces	7	4.5	0	4.5
Potato Chips	42 g	11	2	3	5
Shortening	1 tbsp	13	3.5	4	7.5

Table 17. Total fat, saturated fat, and *trans* fat of selected foods.

Mono- and Polyunsaturated Fatty Acids

Given the recommendation to minimize intakes of saturated and *trans* fatty acids, the majority of fat intake should consist of monounsaturated and polyunsaturated fatty acids.

Monounsaturated and polyunsaturated fats do not raise LDL cholesterol.

Up to 15 percent of your caloric intake should come from monounsaturated fats.

Up to 10 percent of your caloric intake can come from polyunsaturated fats.

Omega-6 to Omega-3 Fatty Acids Ratio

The omega-3 fatty acids seem to act as blood thinners, decreasing the risk of lethal blood clots and possibly staving off hardening of the arteries.

Omega-3 fatty acids are found in tuna, salmon, mackerel, and other fatty fish.

The omega-6 and omega-3 polyunsaturated fatty acids are metabolized using the same series of enzymes. The balance of linoleic and alpha-linolenic acids may be important in determining the amounts of elongated fatty acids in tissue lipids.

The best way to get omega-3 oils is to eat two to three servings of fish per week.

The FNB has not established a recommendation about the omega-6: omega-3 ratio except for pregnant and lactating women (a ratio below 5:1 may be associated with impaired growth in infants).

For more information, see *Omega-3 Fatty Acids* on page 81.

Read the Food Label

Just because a food sounds healthy, it is not necessarily so. Granola, for example, is usually high in fat. Muffins are popular—they taste great. Let us face it—fat tastes good—but so can bagels, which have hardly any calories from fat at all.

The Nutrition Facts panel can help you choose foods lower in saturated fat, *trans* fat, and cholesterol.

To lower your intake of saturated fat, *trans* fat, and cholesterol, compare similar foods and choose the food with the lower combined saturated and *trans* fats and the lower amount of cholesterol.

Table 18 outlines a quiz from the FDA:

If you were going to use one tablespoon of butter or margarine, which of the products in the table would you choose?

Product	Calories	Total Fat, g	Saturated Fat, g	Trans Fat, g	Combined Sat-Trans Fats, g	Cholesterol, mg
Butter	100	11	7	0	7	30
Margarine stick, 80% fat	100	11	2	3	5	0
Margarine stick, 70% fat	90	10	2	2.5	4.5	0
Margarine tub, 60% fat	80	9	1.5	0	1.5	0

Table 18. Four spread choices. Which is the heart-healthy choice?

Butter. This choice contains the highest combined amount of saturated and *trans* fat, and the highest amount of cholesterol.

For many palates, though, it tastes best!

Margarine, 80% fat, stick. This choice does not contain the lowest combined amount of saturated and *trans* fat.

Margarine, 70% fat, stick. This choice does not contain the lowest combined amount of saturated and *trans* fat.

Margarine, 60% fat, tub. Best heart-healthy choice. It has the lowest combined amount of saturated and *trans* fat and no cholesterol.

Heart-Healthy Substitutions

Substitutions can lower your fat intake. Possible substitutions are listed in Table 19.

Making Healthy Fat Choices

Even though monounsaturated and polyunsaturated oils appear to be better for you, do not make the mistake of *adding* fat to your diet. In general, the less fat you eat, the better off you are.

Instead, switch from the more harmful saturated fats to the more benign unsaturated varieties.

You are not helping yourself by eating your bread dipped in olive oil if you are happy to eat it plain. Olive oil, in moderation, might be a better choice than butter.

If You Choose	Instead Of	Fat Saved Per Serving
Angel food cake slice	Doughnut, glazed	14 grams
Bagel	Apple muffin	8 grams
Chestnuts, roasted	Peanuts, dry-roasted	13 grams
Chicken, white, skinless	Chicken, dark, with skin	20 grams
Cocoa powder	Baking chocolate	13 grams
Ham, lean roasted	Salami	8 grams
Jam	Butter	11 grams
Milk, fat-free	Milk, whole	8 grams
Peach	Peach pie	16 grams
Popcorn, hot air	Popcorn, microwave butter	8 grams
Pork loin, trimmed	Pork spareribs	18 grams
Potato, baked	French fries	11 grams
Pretzels	Potato chips	9 grams
Raisin bread, two slices	Croissant, one	10 grams
Salmon	T-bone steak	22 grams
Shredded wheat cereal	Granola	5 grams
Sorbet	Ice cream, premium	25 grams
Spaghetti marinara	Fettuccini Alfredo	90 grams
Taco chips, baked	Taco chips, fried	5 grams
Tuna, water-packed	Tuna, oil-packed	6 grams

Table 19. Heart-healthy substitutions.

Watch Out For Hidden Fat

Avoid undermining healthy foods by dressing them in butter, margarine, mayonnaise, or other high-fat sauces.

One tablespoon of Caesar salad dressing, with 8 grams of fat, can raise the caloric content of half a cup of Romaine lettuce to 88 percent fat.

Reduced broth or puréed vegetables make a healthful low-fat alternative to cream- or butter-based sauces.

A handful of peanuts, granola cereal, egg-laden breads and pastas, nondairy creamers, even some fast food “diet” meals can be high in fat.

A McDonald's fish filet sandwich has 26 grams of fat and 45 milligrams of cholesterol, more than the same restaurant's cheeseburger.

A large bucket of unbuttered movie theater popcorn popped in coconut oil has the equivalent of three days' saturated fat.

Watch Portion Size

One serving of meat or fish is 3.5 ounces; it is about the size of the palm of your hand or a deck of cards.

Steam, Bake, Poach, or Broil

If you do want to sauté, use a nonstick skillet and substitute broth for fat. Alternatively, use vegetable-oil spray. Avoid deep-fat frying.

Choose the Right Fats and Oils

Choose vegetable oils (except coconut and palm kernel oils) and soft margarines (liquid, tub, or spray) over solid shortenings, hard margarines, and animal fats, including butter.

Coconut and palm kernel oils are higher in saturated fat than butter. Canola, olive, almond, peanut, avocado, and certain fish oils are high in monounsaturated fats. Corn, soybean, safflower, sunflower, and sesame seed oils are high in polyunsaturated fats.

Choose Lean Meat in Moderation

When you do eat meat, eat less and eat leaner.

The American Heart Association recommends eating no more than 6 ounces of cooked lean meat, skinless poultry, fish, or seafood daily.

Choose cuts with a minimum of visible fat. Trim all visible fat from meat and remove the skin from poultry before eating.

“Select” grade meats tend to be lower in fat than “Choice” or “Prime.”

Consider Fish

Most fish are lower in saturated fat than meat.

Some fish, such as mackerel, sardines, and salmon, contain omega-3 fatty acids that may offer protection against heart disease.

Go Meatless Occasionally

Prepare legumes (dried peas and beans), pasta, and rice dishes for your main course, using low-fat or fat-free dairy products.

Do not think automatically of cheese as a healthy meat-substitute.

Many cheeses, like ice cream, have 60% to 70% of their calories from fat.

Emphasize Grains, Fruits, Vegetables, and Beans

These filling foods not only serve as stand-ins for richer meat and dairy products, but also contain carotene, vitamins C and E, selenium, and soluble fiber.

High-fat exceptions include coconut, olives, and avocado. Small portions of avocado and olives are okay—they are high in monounsaturates. Avoid coconut, which is high in saturated fats.

Use Fat-free Milk, Avoid Fatty Milk

Choose fat-free instead of whole milk, a frozen fruit juice bar or low-fat frozen yogurt over ice cream; a slice of angel food cake over a brownie.

If you think that 2% milk is low in fat, think again. Two percent refers to fat content by weight. In terms of calories from fat, it is 33%. Whole milk gets one-half its calories from fat.

Fat-free milk has zero calories from fat, and it is a great source of protein, carbohydrate, vitamins, and minerals, including calcium. It is one of the best foods there is.

If fat-free milk tastes too watery, adapt, as you do with any other training program. Let your body adjust. Get used to fat-free milk by

drinking 2% reduced-fat milk for a while, then 1%. Finally, choose fat-free milk.

Consider Nuts in Moderation

Nuts can be heart-healthy. The fat they contain is generally unsaturated.

Nuts are loaded with vitamins B and E; the minerals calcium, selenium, and zinc; and amino acids.

Due to their high caloric content, keep quantities small.

Vegetarian, Health Foods

Do not assume that vegetarian or “health” foods are low in fat. A half cup of granola has a fat calorie ratio of 50 percent—higher percentage of fat than a Milky Way chocolate bar (30 percent).

Restaurant Help

Almost all restaurants have lower-fat items, often noted on the menu. Most chain restaurants have brochures outlining their menu choices and nutrition contents. Ask which fats are being used in the preparation of your food.

- Salads are great—they have lots of vitamins and minerals and are low in fat. However, scoop on a few ounces of oily dressing, and now you have lots of fat and almost no carbohydrate.
- Pancakes or waffles may be a reasonable breakfast menu item when you are on the road and cannot eat your usual muesli or low-fat cereal at home. However, lather on the butter or margarine that is usually provided and fat percentage skyrockets.
- The bagel was a great choice. However, gobs of butter or cream cheese ruin your good selection. Use just a dab if you must, or some jam instead.
- Use mustard instead of mayonnaise on that sandwich.
- Use plain yogurt or salsa on your baked potato instead of butter and sour cream.

- Eating a burger? Have a smaller one with mustard and ketchup, not the ½-pound burger with cheese, bacon, or mayonnaise.
- Mexican food? Choose the burrito instead of the deep-fried chimichanga.

Keep Low-Cal Snacks handy

Keep low-fat, low-calorie snacks around. Low-fat foods: rice wafers, dry cereals (not Granola), whole grain breads, fruits and vegetables, fat-free or low-fat cottage cheese.

Watch Calories

Fats are calorically dense. Fat contains 9 calories per gram, making fat the most concentrated source of calories. Carbohydrate and protein have only 4 calories per gram.

Do not assume that “low-fat” is the same as “low-calorie.” For an example of deceptive labeling of a fat-free product, see the article “*Nutrition Facts*” *Label* in the free supplement to this book available at: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

Read about body fat, obesity, and tips to lose weight in the free supplement to this book available at: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

Alcohol

Calories

Pure alcohol supplies 7 calories per gram.

The typical bottle of beer, glass of wine or spirits drink (shot or mixed drink) each contains the same amount of alcohol.

Many alcoholic beverages contain carbohydrates in addition to alcohol.

A 5-ounce glass of wine, 12-ounce light beer, or 1.5 ounces of 80-proof spirits all have about 100 calories.

Some spirits contain fats. For example, Bailey's Irish Cream contains 40 calories of fat per 1-ounce serving.

Mixed drinks may have more calories. For example, a Pina Colada has about 250 calories.

Alcohol contributes to obesity in those who drink in addition to consuming a "normal" diet. If alcohol replaces food and other beverages, weight may be lost.

Low-carb and no-carb claims on alcoholic beverages are legal—so long as the labels do not say that they help you lose weight. The implication that low-carb beers and wine or carb-free spirits are a boon on a weight-loss program is deceptive.

Hard liquor is distilled and has never contained carbohydrate. "Zero-carb" advertising for vodka and whiskey is deceptive. It is like advertising an apple juice that is "cholesterol-free."

Nearly all weight-loss plans advise cutting out alcohol. Alcoholic beverages provide "empty" calories without vitamin and mineral nutrition; they may loosen resolve to lose weight, and may promote eating "without thinking."

Beverage	Calories	Alcohol cals	Carb cals
Beer, regular, 12 ounces	150	100	50
Beer, "lite" "low-carb", 12 ounce	100		18
Wine, 5-ounces	100	84	16
Spirits, 1½ ounces 80 proof	100	100	0

Table 20. Caloric content of typical alcohol beverages.

Affect on Overall Nutrition

Alcoholic beverages are generally "empty" calories, low in vitamins, mineral, and protein.

Vitamins absorbed through the small intestine by active transport or stored in the liver can be deficient in those who consume alcohol regularly.

Alcohol is associated with vitamin and mineral deficiencies—vitamin A, thiamin (B₁), niacin (B₁₃), pyridoxine (B₆), folate, B₁₂, calcium, magnesium, phosphorus, potassium, and zinc—described throughout this book.

Alcohol interacts with vitamin A, niacin, and iron and is potentially toxic due to those interactions.

Alcohol can contribute to hypoglycemic reactions.

Benefits

Although not normally thought of a nutrient, there is evidence that alcohol may be beneficial.

Heart Disease

The French paradox is a name for the perceived paradox that people in France suffer a relatively low incidence of coronary heart disease despite their diet being rich in saturated fats.

It was thought that France's high red wine consumption might be related to this phenomenon. Medical opinion is moving away from red wine consumption per se as the explanation.

Any form of moderate alcohol consumption may decrease the risk of heart disease, including heart attack.

Half a dozen long-term studies indicating risk reduction are summarized in Table 21.

How this benefit occurs is not certain. Possibilities include: (1) alcohol stimulates reverse cholesterol transport, a process by which cholesterol is removed from the tissues (including the walls of the coronary arteries), (2) alcohol improves HDL—good cholesterol, or (3) alcohol improves blood clotting problems.

Participants	Duration	Association with moderate consumption compared with non-drinkers.
Kaiser Permanente: 123,840 men and women aged 30+	10 years	40% reduction in fatal myocardial infarction, 20% reduction in cardiovascular mortality; 80% increase in fatal hemorrhagic stroke.
Nurses' Health Study: 85,709 female nurses aged 34-59	12 years	17% lower risk of all-cause mortality; an earlier report showed a 40% reduction in risk of CHD and 70% reduction in risk of ischemic stroke.
Physicians' Health Study: 22,071 male physicians aged 40-84	11 years	30-35% reduced risk of angina and myocardial infarction, 20-30% reduced risk of cardiovascular death.
American Cancer Society: 489,626 men and women aged 30-104	9 years	30-40% reduced risk of cardiovascular death.
Eastern France: 34,014 men and women	10-15 years	25-30% reduced risk of cardiovascular death.
Health Professionals Follow-up Study: 38,077 male health professionals aged 40-75	12 years	35% reduced risk of myocardial infarction.

Table 21. Studies of alcohol consumption and cardiovascular disease.¹⁸

¹⁸ Harvard School of Public Health. <http://www.hsph.harvard.edu/nutritionsource/alcohol.html>. Accessed 10-09-2004.

Other Benefits

Alcohol may decrease the incidence of gallstones and Type II diabetes. Results are preliminary.

Alcoholic beverages may contribute to the flavor to foods—when ingested with foods or when cooked with them. Cooking burns off alcohol.

Alcohol consumption is part of some religions and their rituals. It is banned or discouraged in others.

Toxicity¹⁹

Alcohol is associated with or causes:

- **Addiction.** Alcohol addiction (alcoholism) is a major health problem. Withdrawal symptoms include hyperexcitability, alterations in perception, toxic psychosis including hallucinations.
- **Cancer.** Alcoholics have a cancer rate 10 times that of the general population. The greatest increases over expected rates occur in the head and neck, esophagus, stomach, liver, pancreas, and breast.
- **Heart disease.** Increases blood pressure and adversely affects heart muscle contraction and heart rhythm.
- **Gastrointestinal problems:** Alcohol results in inflammation of the esophagus and stomach. It is associated with gastrointestinal bleeding, abdominal pain, and diarrhea.
- **Liver disease.** Alcohol causes fatty accumulation, hepatitis, cirrhosis, and liver failure.
- **Pancreatitis.** Both acute and chronic.

¹⁹ Principle source: Harrison's Principles of Internal Medicine, 12th ed. McGraw-Hill. New York. 1991.

- Hematopoietic system. Interferes with the formation of red blood cells, white blood cells, and platelets.
- Muscle dysfunction. Myopathy including pain and swelling.
- Pregnancy effects. Including congenital birth defects and fetal alcohol syndrome.
- Skeletal system alterations: Alcohol alters calcium metabolism and increases the risk of fractures and osteonecrosis (bone death).
- Sexual effects: Men: Alcohol decreases erectile capacity and causes testicular atrophy. Women: Alcohol may cause a loss of periods, ovarian atrophy, infertility, and spontaneous abortion.
- Central nervous system/psychiatric impact:
 - Acute behavioral effects. Blackouts. Disturbed sleep.
 - Peripheral and central neuropathies.
 - Problems with thinking: Alcohol impairs all aspects of mental status—orientation, concentration, memory, mood, judgment, and insight. It is associated with depression, anxiety, personality change, paranoid delusions, and psychoses including hallucinations.
 - Alcohol is a central nervous system depressant; it impairs the ability to drive, slows down reaction time, and increases poor decision-making.
 - Dementia.

Other Toxic Effects

- Trauma: Those who drink regularly have a higher rate of deaths from injury, including work-place injury, motor-vehicle accidents, and recreational accidents.
- Social problems including work absence and poor performance, and interpersonal problems including divorce.
- Numerous drug interactions.

Athletic Effects

Ergogenic Effects

Alcohol has some acute anti-anxiety and anti-tremor effects. These theoretically might help in sports such as archery, billiards, or riflery. There is no convincing evidence that alcohol enhances performance in any sport.

Ergolytic Effects

Studies examining aerobic capacity or performance time to exhaustion always show worse performance by subjects who have consumed alcohol—even low to moderate doses.

Perception of exercise exertion may not change—athletes may think that they are doing fine.

Here are some of the specific problems for athletes:

- Slows reaction times. If it muddles your thinking and causes you to miss a key move in a race, that is one thing. Death is another. Alcohol is the number one killer of teens and young adults in the US. One-third of Americans who die each year from bicycle accidents are found to be riding under the influence of alcohol.
- Displaces other valuable food sources and is associated with many nutritional deficiencies described above and throughout this book.
- Poor replacement fluid. Although portrayed as a replacement beverage in advertising, it may worsen dehydration and usually does not provide enough sodium or carbohydrate for glycogen refueling.
- Heart. Alcohol decreases heart rate and the ability of the heart to contract. Stroke volume, work capacity, peak lactate levels, blood pressure and respiratory dynamics are all adversely affected.

- Hormones. Alcohol is associated with decreased hormone levels, including testosterone levels.
- Muscle cells. Alcohol is poisonous to muscle cells. It is associated with reduced muscle mass and reduced ability to contract muscle cells.
- Temperature regulation. Alcohol increases the risk of hypothermia.
- Liver toxicity. Alcohol is metabolized preferentially in the liver, interfering with glucose production, increasing the production of lactate, and increasing fat accumulation.
- Lungs. Alcohol can worsen exercise-induced asthma.
- Red blood cells. Alcohol interferes with red blood cell formation and is associated with anemia.

Summary

Alcohol may reduce the risk of some cardiovascular diseases, including heart attack. With many negative effects on the rest of your body and on athletic performance, alcohol is not recommended as a source of calories.

Part 3:

Sports Foods

Sports Drinks

These are marketed as a source of fluids, calories, and electrolytes for use before, during, or after exercise.

Providing fluids and calories is their primary purpose.

Table 22, below, lists selected sports drinks. These typify manufacturer offerings. The inclusion of products and the omission of others is not an endorsement of the products listed or a criticism of those omitted.

Most sports drinks are about 6% concentrations of carbohydrate. This means most sports drinks contain 100 to 125 calories per pint (one-half quart, 500 milliliters).

The only electrolyte that has consistently been shown to be important for athletes is sodium, and only when more than several quarts (liters) of fluids have been lost. For more information about sweat mineral losses, see page 21.

Some products list a range of mixing instructions. For example: mix 1 to 1½ scoops per 16-ounce serving. Where ranges are suggested, the upper end of the suggested range is reported in the table. After all, one always has the option of diluting any product from its recommended concentration. Increasing the concentration of carbohydrate by adding more scoops than recommended is a strategy some athletes try, and generally abandon. This gives more calories per unit volume but results in more gastrointestinal upset.

When the manufacturer specifies the number of scoops, but not the volume of fluid to be used, 16-ounces are used.

One way to increase calories without gastrointestinal upset is to use maltodextrins instead of simple sugars. For more information about maltodextrins, see page 51.

Nutritional contents are based on information provided on the manufacturers' websites, accessed October, 2004.

Label conflicts are relatively common and are noted. For example, The Coca-Cola Company reports on the food label that there are 39 grams of carbohydrate and 140 calories in a 12-ounce can. Since there are 4 calories per carbohydrate gram, one would expect 156 calories per can. Where total calories are not given for a

product, we have calculated based on 4 calories per gram of carbohydrate, 4 calories per gram of protein, and 9 calories per gram of fat.

Small differences may be explained by rounding.

Product	Image	Manufacturer	Marketed For	Calories (16 oz)	Carb Cal (% sol'n, total g, complex g)	Carb Type	Protein Cal (g)	Fat Cal (total g, sat g)	Sodium (mg)	Potassium (mg)	Other
Accelerade Fruit Punch		PacificHealth Laboratories pacifichealthlabs.com	Hydration, energy, muscles	160	112 (6%, 28, 1)	Sucrose Fructose	27 (6.7)	12 (1)	253	87	Magnesium 100 mg, Vitamin C, Vitamin E.
Carbo Gain		NOW Foods nowfoods.com	Before, during, and after exercise	190	190 (?*% 47, 45)	Maltodextrin	0	0	0		May double concentration.
Cytomax		CytoSport cytosport.com	Before, during, and after exercise	142	120 (6% 30, 13)	Fructose Maltodextrin	0	0	150		L-glutamic acid, inosine, L-glutamine, chromium, herbs, alpha L-poly lactate. At 1½ scoops Label conflict.
Endurance		PowerBar powerbar.com		180	140 (7% 34, 16)	Maltodextrin Dextrose Fructose	0	0	320	20	Magnesium 8% DV.
Extran Thirstquencher		Nutricia extranusa.com	Before, during, and after exercise	90	90 (?*% 22, 7)	Fructose Maltodextrin	0	0	122	99	

Product	Image	Manufacturer	Marketed For	Calories (16 oz)	Carb Cal (% sol'n, total g, complex g)	Carb Type	Protein Cal (g)	Fat Cal (total g, sat g)	Sodium (mg)	Potassium (mg)	Other
Extran Citron		Nutricia extranusa.com	Before, during, and after exercise	760	760 (36%, 190, 161)	Glucose	0	0	47		Thiamin.
Gatorade Lemon lime		The Gatorade Company gatorade.com	Before, during, and after exercise	100	100 (6%, 28, 0)	Sucrose Glucose Fructose	0	0	220	60	Phosphate. Lemon lime, 15 others.
GU20		Sports Street Marketing gusports.com	During exercise	100	104 (6%, 26, 22)	Maltodextrin Fructose	0	0	240	40	Lemon lime, raspberry, orange.
RevengePro		Champion Nutrition champion-nutrition.com	During exercise	100	80 (4%, 20, 8)	Maltodextrin, fructose, glucose	16 (4)	4 (0.5, 0g)	85	160	Multivitamins/ minerals, protein, ribose, ginseng, glucosamine, willow bark, feverfew, periwinkle, chromium, caffeine 30 mg.
Sustained Energy		Hammer Nutrition e-caps.com	During exercise	343	292 (?% 73, 68)	Maltodextrin	42 (10.5)	9 (1,0)	112		Protein, L-carnosine, L-carnitine complex, choline, chromium.

Product	Image	Manufacturer	Marketed For	Calories (16 oz)	Carb Cal (% sol'n, total g, complex g)	Carb Type	Protein Cal (g)	Fat Cal (total g, sat g)	Sodium (mg)	Potassium (mg)	Other
WARPaide		smartFUEL smartfuel.com	During exercise	140	140 (7%, 36, ?)	Dextrose, Maltodextrin, Fructose	0	0	135		Taurine.
Coke		Coca-Cola Company coke.com	General public	190	208 (11%, 52, 0)	Fructose Sucrose	0	0	67		Caffeine 46 mg.
Apple Juice		Mott Company motts.com	General public	234	232 (12%, 58, 0)	Fructose	0	0	14	590	

Table 22. Sports drinks. Selected nutritional content. *Percent concentrations of maltodextrin products depend upon the maltodextrin used and are unknown unless disclosed by the manufacturer.

Sports Recovery Drinks

These are marketed as a source of fluids, calories, electrolytes, protein, and occasionally fat for use after exercise.

Table 23, below, lists selected sports recovery drinks. These typify manufacturer offerings. The inclusion of products and the omission of others is not an endorsement of the products listed or a criticism of those omitted.

Providing fluids and calories is the primary athletic need. Providing protein is the marketing hook. If it was not for the protein, recovery drinks might be indistinguishable from traditional sports drinks.

The value of protein in recovery drinks is doubtful. For more information about the role of protein and fat in recovery, see page 66.

The only electrolyte that has consistently been shown to be important for athletes is sodium, and only when more than several quarts (liters) of fluids have been lost. For more information about sweat mineral losses, see page 21.

Nutritional contents are based on information provided on the manufacturers' websites, accessed October, 2004.

Label conflicts are relatively common and are noted. Small differences may be explained by rounding.

Recovery Drink Product	Image	Manufacturer	Total Calories (16 oz)	Carb Cal (% sol'n, total grams, complex grams)	Protein Cal (grams)	Fat Cal (total grams, saturated grams)	Sodium, mg	Potassium (mg)	Other
BioFIX <i>Peach mango</i>		smartFUEL smartfuel.com	290	236 (12% 59, ?)	44 (11)	18 (2)	340		Multivitamins/minerals, L-carnitine, L-ketoglutaric acid, N-acetylcysteine, betaine HCl, inositol
Cytomax Recovery		CytoSport cytosport.com	696	144 (7%, 36, 20)	208 (52)	324 (36, 16)	200	480	Multivitamins/minerals Dose is 2-4 scoops per 12 ounces. Content is given for 4 scoops in 16 ounces.
Endurox R4 <i>Lemon lime</i>		PacificHealth Laboratories pacifichealthlabs.com	360	280 (15%, 70, 16)	70 (17)	10 (1)	280	160	L-arginine, vitamin C, vitamin E, calcium, magnesium

Recovery Drink Product	Image	Manufacturer	Total Calories (16 oz)	Carb Cal (% sol'n, total grams, complex grams)	Protein Cal (grams)	Fat Cal (total grams, saturated grams.)	Sodium, mg	Potassium (mg)	Other
PowerBar Recovery		PowerBar powerbar.com	180	160 (40, 20)	24 (6)	0	500		

Table 23. Sports recovery drinks. Selected nutritional content.

Sports Energy Bars

These are a convenient source of calories for use before, during, or after exercise.

Providing calories is their primary purpose. Most contain about 200 calories per serving/packet.

Table 24, below, lists selected sports energy bars. These typify manufacturer offerings. The inclusion of products and the omission of others is not an endorsement of the products listed or a criticism of those omitted.

Originally conceived as convenient energy sources for fueling during workouts, niche markets have developed for bars before and after workouts, for women, for those trying to lose weight, for those on 40-30-30 diets, and for those on low-carb diets.

The Clif Bar and PowerBar products illustrate some of the many carbohydrate, protein-carbohydrate, and reduced-calorie offerings.

Carbohydrate is the most important and usually main source of energy for during-exercise bars. Bars marketed for recovery (after exercise) often contain protein, generally about 20% of calories. Although the marketing of protein for recovery has been heavy, the science underlying marketing claims is light. For more information on this topic read the information starting on page 66.

Energy bar companies attempting to provide calories while also catering to those trying to lose weight, following the 40-30-30 program, or being part of the low-carb craze present marketing

challenges perhaps best described charitably as oxymoronic (described uncharitably as moronic).

The only mineral that has consistently been shown to be important for athletes is sodium. For more information about sweat mineral losses, see page 21.

Other ingredients are of questionable value. Other ingredients include anti-oxidants, electrolytes, vitamins, minerals, amino acids, and herbs.

Most products are best accompanied by at least 8 ounces of water to prevent gastrointestinal upset.

Although convenient, few non-athletes describe these products as tasty; some have the mouth feel of cardboard. Although athlete palates may get used to these products, few in the general population prefer their taste to Milky Way or Snickers chocolate bars.

Easy, relatively inexpensive, tasty, and potentially more nutritious alternatives include bananas, peanut butter and jelly sandwiches, Fig Newtons, PopTarts, and relatively low-fat chocolate bars like Milky Way.

Nutritional contents are based on information provided on the manufacturers' websites, accessed October, 2004.

Label conflicts are relatively common and are noted. Small differences may be explained by rounding.

The nutritional content of the *italicized* flavor is given.

Product	Image	Manufacturer	Market	Size	Calories	Carb Cals (total g, complex g)	Protein Cals (g)	Fat Cals (total g, saturated g)	Sodium, mg	Flavors	Other
Clif Bar		Clif Bar Inc. clifbar.com/	Before, during	1.4 oz	230	172 (46, 20)	40 (10)	30 (3, 0.5)	90	Apricot Black cherry almond Carrot cake Chocolate almond fudge Chocolate brownie 10 others.	Multi- vitamins/ minerals
Clif Builder's		Clif Bar Inc. clifbar.com	After Protein replacement	2.4 oz 68 g	270	120 (30, 7)	80 (20)	70 (8, 5)	260	Chocolate Peanut butter Cookies 'n cream	Multi- vitamins/ minerals
Clif Luna		Clif Bar Inc. clifbar.com	Women Lower cal	1.7 oz 48 g	170	110 (29, 9)	40 (10)	20 (2, 0.5)	160	Caramel apple Dulce de leche Sweet dreams 16 others	Multi- vitamins/ minerals Green tea
Clif Mojo		Clif Bar Inc. clifbar.com	Salty Snack alternative	1.6 oz 45 g	190	100 (25, 13)	36 (9)	50 (6, 1)	260	Honey roasted peanut Mixed nuts Fruit nut Mountain mix	
Extran Endurance Bar		Nutricia extranusa.com	Before, after	2.1 oz 60 g	223	200 (50, 17)	4 (1)	18 (2)	126	Apricot	Multi- vitamins/ minerals
PowerBar Harvest Bar, Dipped Harvest		PowerBar Inc. powerbar.com	Before, during	2.3 oz	240	180 (45, 22)	28 (7)	35 (4, 0.5)	80	Apple crisp Cherry crunch Strawberry 7 others	Multi- vitamins/ minerals

Product	Image	Manufacturer	Market	Size	Calories	Carb Cals (total g, complex g)	Protein Cals (g)	Fat Cals (total g, saturated g)	Sodium, mg	Flavors	Other
PowerBar Performance Energy Bar		PowerBar Inc. powerbar.com	Before, during	2.3 oz	230	180 (45, 24)	10 (1)	25 (2.5, 0.5)	90	Malt nut Cappuccino Cookies & cream Apple cinnamon Banana 7 others	Multi- vitamins/ minerals, amino acids
PowerBar Pria		PowerBar Inc. powerbar.com	Before, during Low cal	1.0 oz	110	64 (16, 6)	20 (5)	27 (3, 2)	80	Choc honey graham Choc peanut crunch Crème caramel crisp 4 others	Multi- vitamins/ minerals
PowerBar Protein Plus		PowerBar Inc. powerbar.com	After Protein replacement	2.8 oz	270	136 (36, 15)	96 (24)	45 (5, 3)	140	Choc fudge brownie Choc peanut butter Cookies & cream Vanilla yogurt	Multi- vitamins/ minerals
Balance Bar		Balance Bar balance.com	40-30-30	50 g	200	84 (22, 4)	56 (14)	60 (6, 2.5)	230	Peanut butter Almond brownie Chocolate 5 others.	Multi- vitamins/ minerals
Milky Way		Mars Inc. mars.com	Snack bar	2.1 oz	270	164 (41, 5)	8 (2)	90 (10, 5)	95	Chocolate candy bar	

Table 24. Sports energy bars. Selected nutritional content.

Sports Gels

These are a convenient source of calories for use during exercise.

Most contain about 100 calories per serving/packet. Some come in packages of two to a dozen servings.

Carbohydrate is the most important and usually the exclusive source of energy. Most carbohydrate is in the form of maltodextrins. Glucose, fructose, and other simple sugars are also used.

Table 25, below, lists selected sports gels. These typify manufacturer offerings. The inclusion of products and the omission of others is not an endorsement of the products listed or a criticism of those omitted.

Unlike bars or traditional foods, the gels have no fiber, and no starches such as rice or potato. The maltodextrin percentage content can therefore be inferred by the grams of complex carbohydrate relative to the total carbohydrate content. Read more about maltodextrins on page 51.

Many contain up to 50 milligrams of caffeine, about half the content of a cup of coffee.

The only mineral that has consistently been shown to be important for athletes is sodium. For more information about sweat mineral losses, see page 21.

No sport gels contain fat.

Other ingredients are of questionable value. Other ingredients include anti-oxidants, other electrolytes, and amino acids.

Although some have amino acids, the content is insufficient to total to 1 gram of protein for labeling, except for the Accel gel product.

Most are best accompanied by at least 8 ounces of water to prevent gastrointestinal upset. Half-strength fruit juice in a standard waterbottle, “real food,” yields the same calories with less expense.

Gel consistency is often described as being like syrup, cake frosting, or toothpaste.

Nutritional contents are based on information provided on the manufacturers’ websites, accessed October, 2004.

The nutritional content of the *italicized* flavor is given.

Product	Image	Manufacturer	Size	Calories	Carb Cals (total g, complex g)	Protein Cals	Fat Cals	Sodium, mg	Flavors	Other
Accel Gel		PacificHealth Laboratories, Inc. pacifichealthlabs.com	41 g	112	90 (20g, 10g)	22	0	95	<i>Vanilla</i> Chocolate (20 mg caffeine) Strawberry kiwi	Vitamin C, iron, potassium 45 mg

Product	Image	Manufacturer	Size	Calories	Carb Cals (total g, complex g)	Protein Cals	Fat Cals	Sodium, mg	Flavors	Other
Carb-Boom		Carb-BOOM, Inc carbboom.com	41 g 1.4 oz	110	110 (27g, 24g)	0	0	50	Vanilla orange (50 mg caffeine) Apple cinnamon Banana peach Chocolate cherry (50 mg caffeine) Strawberry kiwi	Potassium 50 mg.
Clif Shot		Clif Bar Inc. clifbar.com	32 g 1.1 oz	100	100 (25g, 17g)	0	0	40	Viva vanilla Cola Buzzzzz (40 mg caffeine) Mmm...chocolate Mocha mocha (40 mg caffeine) Razz sorbet Sonic strawberry (40 mg caffeine)	Potassium 25 mg, magnesium
Enervit Enervitene Sport Gel		Enervit enervit.it	30 g	120	120 (30g, 14g)	0	0	0	Cola Lemon Orange	Fructose, B-vitamins
Gu Energy Gel		Sports Street Marketing gusports.com	32 g 1.1 oz	100	100 (25g, 22g)	0	0	40	Vanilla bean (20 mg caffeine) Banana blitz Chocolate outrage (20 mg caffeine) Orange burst (20 mg caffeine) Tri-berry (20 mg caffeine)	Amino acids, calcium, potassium 35 mg, herbs (cola-nut, chamomile, ginger), vitamin C, vitamin E
Hammer Gel		Hammer Nutrition e-caps.com/	0.8 oz	91	91 (23g, 21g)	0	0	27	Apple Cinnamon Banana Chocolate Espresso (50 mg caffeine) Orange Plain Raspberry Vanilla	Amino acids, potassium.

Product	Image	Manufacturer	Size	Calories	Carb Cals (total g, complex g)	Protein Cals	Fat Cals	Sodium, mg	Flavors	Other
PowerGel		PowerBar Inc. powerbar.com	41 g	110	110 (26g, 20g)	0	0	45	<i>Vanilla</i> Chocolate (25 mg caffeine) Green apple (25 mg caffeine) Lemon lime Raspberry cream Strawberry banana (25 mg caffeine) Tangerine (50 mg caffeine) Tropical fruits	Amino acids, potassium 45 mg, chloride 90 mg, vitamin C, vitamin E Caffeinated contain kola nut and ginseng.

Table 25. Sports gels. Selected nutritional content.

Part 4:

Ergogenics & Ergolytics

Ergogenics Overview

Ergogenic²⁰ means work producing. Ergogenics include performance-enhancing substances, devices, and techniques.

What we will discuss here are supposed ergogenic nutritional aids and supplements; ingested substances that allegedly improve performance.

Keep in mind that there is a big difference between something that is purported or promoted to improve performance and something that really does.

Ethics question: Should one be allowed to take something to make one stronger or go faster? It is not a black and white issue, and not a question that I will discuss here.

Competitor question: Some of these substances are banned; some are not. Governing bodies ban compounds for many reasons, including safety, creating a level playing field, and prohibiting masking agents that make the detection of other banned substances more difficult. What is banned for one sport or federation may not be in another. For example, bicycle racers are subject to different rules than triathletes.

Legal question: Legality, another topic, is a criminal issue. Some ergogenic aids require a prescription.

If you compete, you should assume that anything you ingest except “real food” is banned unless you know otherwise. Some over-the-counter decongestants, used for colds and the flu, are banned. Some nose sprays are banned. Many teas and herbal remedies contain banned substances. Many pain pills, high blood pressure medications, and asthma medicines are banned.

²⁰ From the Greek *ergo-* + *-genic*.

If you need to know about a substance, visit the US Anti-Doping Agency website at www.usantidoping.org or call the USADA drug hotline at 800-233-0393.

If ingested substances are going to improve performance, it is usually because strength, oxygenation, or anaerobic tolerance is improved. The following is a list of the most common purported ergogenic aids, their properties, side effects, status (banned or not, legal or not, need for prescription), and my recommendations as to their use.

Let me be clear: If a substance is banned, illegal, or dangerous, it cannot be recommended.

Most banned substances do not have a beneficial effect on performance. That is because very few substances, banned or not, improve performance. Very few substances have been shown to improve performance over time.

Most newly promoted ergogenics prove disappointing. Occasionally a study looks promising. More often than not, follow-up studies show little, if any effect.

Indeed, if you were a betting man/woman and always took the position that the latest thing was useless, you would probably end up ahead.

For information about ergogenic quackery, see page 133.

Knowledge and Frequency of Use

Many studies of athletes have shown that they have important deficiencies in knowledge about supplements.

Supplements are used by over 90% of athletes in some sports. Intakes are higher in men than in women. In high school and college, progressively more athletes use supplements as academic class (freshman through senior) advances. The most popular supplements are vitamins and minerals, creatine, and protein powders.

Vitamin and mineral intakes over 10 times the US Recommended Daily Allowances (RDA) are common. Excessive RDA intakes are more likely to hurt, rather than help, performance.

A sample of competitive bodybuilders found that their urine and blood supplement levels were high enough to place them at high risk for nutrient toxicities.

A study a few years ago found that in one high school about 20% of male and 1% of female athletes used performance enhancing substances. When asked whether they would take such substances if they would guarantee a college scholarship but take 20 years off their lives, 6% said “yes.”

Substance abuse among high school athletes is higher than for the general high school population. In one study, more than one-fifth of athletes reported having been drunk and 25% having been drinking and driving in the last month.

Studies show that about 50% of college students take or use aspirin, caffeine, rubdown ointments, sports drinks, or vitamins to help with sport performance.

US college wrestlers widely use supplements. Almost 40% take creatine, 30% protein powders, 5% androstenedione, 15% caffeine, and 5% ephedrine. The NCAA bans some supplements.

About 80% of Navy Seals take nutritional supplements.

20% of athletes in one study used supplements, but were unable to explain why—for what purpose, or what they were hoping to achieve.

Ergogenic Products

A list of popular or promoted potentially ergogenic products follows.

Look Elsewhere in This Book

For amino acids, see the section incorporated into the discussion about protein on page 63.

For discussion about antioxidants, see the chapter beginning on page 25.

For a specific discussion of an individual vitamin or mineral, see the chapter on that specific vitamin or mineral. For a more general discussion about the ergogenic and ergolytic effects of vitamins and minerals, see page 126.

5-Hydroxytryptophan (5-HT)

Not banned.

Studies have not shown performance benefit.

Not recommended.

5-Methyl-7-Methoxyisoflavone

Not banned.

Treated subjects had a decrease in percent body fat in a study that also found placebo-treated healthy, resistance-trained men who maintained consistent training and dietary habits significantly increased their percent body fat.

Why percent fat increased in the placebo group, when diet and exercise were supposedly constant, was not explained.

Not recommended.

Amino Acids and Enzymes

Not banned.

See discussion under protein, athletic considerations, on page 63.

Not recommended.

Acetazolamide

Not banned. Prescription,

Acetazolamide (Diamox), used to help prevent acute mountain sickness, was shown to impair performance when taken at sea level.

Not recommended unless altitude sickness a problem.

Albuterol

Banned without governing body preregistration. Prescription.

See asthma medications.

Avoid without medical need.

Anabolic Steroids

Banned. Prescription.

Caution: Anabolic steroids are banned in most sports and their side effects are well-known, including risk of cardiovascular disease.

Good studies regarding anabolic steroids are few.

Past research was aimed at showing either performance-enhancing effects or side effects. For good reason, athletes, the press, sports governing bodies, etc., are so down on steroids that very little scientific research is being pursued.

Steroids probably do help to increase muscle mass by stimulating protein synthesis. This increases muscular strength. The use of anabolic steroids requires workouts to achieve benefit.

Anabolic steroids may increase hemoglobin levels, which may result in increased oxygen-carrying capabilities of blood and increased aerobic capacity.

Side Effects

For those with medical conditions associated with low levels of steroids, hormone replacement is relatively safe. Many athletes use doses far beyond the normal range of human production. These are the athletes who tend to suffer serious side effects.

The side effects include aggression, fluid retention, acne, liver abnormalities, development of male sex characteristics (deeper voice, more hair, breast atrophy) in women, and shrinking testicles in men.

Even in modest doses, anabolic steroids use is associated with adverse lipid effects. The effects may disappear when use stops. The long-term effects are uncertain.

Some steroids increase not only androgen (“male”) but also estrogen (“female”) hormone levels.

Steroids are illegal and the risks are great if an athlete using them is caught. They can be obtained only with a prescription or on the black market.

Avoid.

Androstenedione

Banned.

See anabolic steroids.

Avoid.

Antidepressants

Not banned.

Prescription drugs (for example Prozac, Wellbutrin, Zoloft, amitriptyline, desipramine, imipramine).

Antidepressants may improve athletic performance by reducing negative hormonal consequences of overtraining. There are sound physiologic reasons why they may work.

They are very helpful in depression, and since overtraining and depression are linked, they can be helpful to some athletes.

Some believe these medicines may help performance even in the absence of depression. A few studies have suggested that these prescription medicines enhance athletic performance; others show no improvement. One study found worsened performance.

Depending upon the specific medication, common side effects include jitteriness, insomnia, sleepiness, and sexual dysfunction (delayed orgasm).

Avoid without medical need.

Anti-inflammatories—NSAIDs

Not banned. May be prescription.

See NSAIDs.

Consider.

Antioxidants

Not banned.

No evidence of ergogenic effect. See the discussion on page 25.

Not recommended.

Aspirin

Not banned.

See NSAIDs.

Consider.

Arginine

Not banned

See discussion under protein, athletic considerations, on page 63.

Not recommended.

Asthma Medications

Banned without governing body preregistration.

These medications open the airways of those with reversible airways obstruction. Proponents believe they may help nonasthmatics as well. Side effects are like those of caffeine: for example, jitteriness, palpitations, and anxiety.

Formoterol has been shown to have no effect on cycling performance in nonasthmatics.

Salbutamol: In one study, this common asthma medicine helped one-hour time trial performance whether cyclists were asthmatic or not. It did not increase erythropoietin levels or red cell production.

Avoid without medical need.

Bee Pollen

Not banned.

No evidence of ergogenic effect.

Not recommended.

Beta-Carotene

Not banned.

Little evidence of ergogenic effect.

Not recommended.

Beta-Ecdysterone

Banned by some sports organizations. A herbal extract, touted for anabolic effects.

Studies of effectiveness and toxicity are lacking.

Avoid.

Beta-Hydroxy-Beta-Methybutyrate (HMB)

Not banned.

See HMB.

Avoid.

Bicarbonate

Not banned.

Sodium bicarbonate is thought by some to buffer lactic acid, thereby improving performance.

Studies are mixed, mostly negative. Its greatest potential may be in anaerobic events. Diarrhea is a common problem.

Not recommended.

Blood Doping and Erythropoietin (EPO)

Banned.

Blood doping is blood transfusion.

EPO is a prescription drug.

EPO is a hormone that stimulates the body to make more red blood cells. The purpose is to boost the oxygen-carrying capacity of the blood.

EPO is commonly used in medicine when patients have hematocrits around 25%. It is used to boost hematocrits to about 35%. Athletes use EPO to boost levels to 50% and more.

Blood doping and EPO work. Testing and detection is becoming easier.

An increase in blood thickness is a problem, especially in athletes who self-medicate and overdo it. EPO has been linked to several cycling deaths and is too dangerous to use.

Avoid.

Bovine Colostrum

Not banned.

Bovine colostrum (the early milk-like product of new cow mothers) is an expensive and controversial supplement used by Australian Institute of Sport cyclists, among others.

One study found that supplementation did not increase human growth hormone or insulin-like growth factor.

It may increase some immune markers in blood.

Whether this translates to improved human performance is uncertain.

Not recommended, unless you are a newborn calf.

Branched Chain Amino Acids

Not banned.

See discussion under protein, athletic considerations, on page 63.

Not recommended.

Caffeine

May be banned over certain limits.

Caffeine is generally accepted as ergogenic. Many, but not all studies have shown it improves performance in quantities up to the equivalent of several cups of coffee.

How it works is not certain. Reports have suggested it helps glycogen use, improves fat utilization, dilates coronary arteries, or improves the function of the central nervous system. It helps get some people going and reduces perceived exertion.

Coffee-drinking athletes sometimes stay away from caffeine for several days before competition, hoping for an improved ergogenic effect with ingestion at the time of competition. Withdrawal side effects can be a problem. A study of the length of time needed to produce an ergogenic effect in habitual coffee drinkers found 12 hours as effective as 4 days.

Side Effects

Coffee is potentially ergolytic—it may worsen performance. Read more on page 125.

Caffeine is a stimulant.

It is a diuretic (promotes dehydration) and causes gastrointestinal distress—bowel cramps and diarrhea.

Caffeine and ephedrine supplementation significantly raised heart rate, blood pressure, and resting energy expenditure.

Caffeine resulted in what turned out to be a poor pacing strategy in a 100-kilometer cycling test of anaerobic and aerobic performance. Riders began too quickly; they later faded.

In some sports it is banned over certain amounts, for example, at levels over 12 micrograms per milliliter of urine—equivalent to about 8 cups of coffee.

Consider.

Calcium Pyruvate

Not banned.

No evidence of ergogenic effect.

Not recommended.

Calories

Not banned.

They are vital for events lasting more than a couple of hours.

Inadequate caloric intake while exercising commonly limits performance.

Read more about solids and solutions for athletes throughout *Part 2, Calories*, beginning on page 34, and in *Workout & Event Nutrition* on page 11.

Endorsed.

L-Carnitine

Not banned.

Carnitine, touted as increasing fat metabolism, can be synthesized naturally in the body from the amino acids lysine and methionine. Minor evidence suggests an ergogenic effect, but most studies show no effect. Some forms of carnitine are associated with muscle weakness.

Read more about L-carnitine in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Not recommended.

Chromium

Not banned.

The role of chromium in protein synthesis is the basis for claims of its anabolic benefits. Positive studies are of low quality, and current studies do not show a benefit. The long-term safety of the picolinate version is uncertain—side effects may include cancer and anemia.

Read more about the ergogenic and ergolytic effects of minerals on page 126.

Not recommended.

Chrysin

Banned by some sports organizations including the NCAA.

Found in the herb *Passiflora incarnata*, the flavone chrysin is an aromatase inhibitor. Body-builders use it in the belief that it prevents the aromatization (degradation) of testosterone, therefore helping to maintain or increase testosterone levels.

Chrysin supplements have been found to be contaminated with anabolic steroids.

Limited studies do not find an ergogenic benefit.

Avoid.

Citrulline Malate

Not banned.

See discussion under protein, athletic considerations, on page 63.

Not recommended.

Clenbuterol

Banned. Prescription for veterinary use only.

This asthma-like drug used in animals is thought to have anabolic effects. It is a relatively commonly-used banned substance used to increase lean body mass. A study in horses showed that chronic use may worsen aerobic performance and recovery.

Avoid.

Codeine

May be banned. Some prescription.

A narcotic.

Almost all narcotics worsen aerobic athletic performance because they depress the central nervous system. Often sedating, they decreased focus. A loss of skills, among other side effects, may create safety issues.

Avoid.

Cordyceps Sinensis

Not banned.

Limited studies. In one study, this herb did not improve endurance performance in competitive male cyclists.

Not recommended.

Corticosteroids

Banned without governing body preregistration. Prescription.

These hormone products may be inhaled or injected. They can help a wide variety of inflammatory medical problems and so help performance. Inhalation of corticosteroids, or injection into a muscle or joint for local problems, requires prompt notification of national anti-doping agencies (e.g. USADA).

Avoid without medical need.

Creatine

Not banned.

Creatine is one of the hottest performance-enhancing supplements. It is also one of the most studied.

The body's own creatine phosphate is important for short, anaerobic efforts. The question is whether oral ingestion succeeds in getting creatine to the muscles to improve performance.

Over the years, the consensus has been that it will not help aerobic performance activities such as most bicycling events.

It may or may not work for sports with repeated anaerobic efforts such as track cycling, hockey, or football. It may be helpful for resistance (weight) training.

Meta-analysis (statistical summary review) of creatine and anaerobic performance concluded that creatine supplementation does not improve anaerobic performance.

Some studies have suggested that coaches, sport scientists, and physicians should discourage creatine use because it is associated with more potentially dangerous ergogenics (that is, that it “may lead to harder stuff”).

Some feel that if creatine is taken, it should be ingested along with glucose. Some studies seem to indicate that carbohydrate supplementation alone may increase performance as much as creatine.

Side Effects

Creatine is not without potential side effects. Studies have suggested that:

- Creatine may be a problem in the heat—it may be related to cramping and injury. Some studies show this, others do not.
- It may increase blood pressure.
- It may increase compartment pressure. Pressure within a confined space may reduce blood flow.
- Creatine seems to increase body weight—probably not good for climbers.
- It may increase the risk of dehydration.
- It may cause upset stomach.
- It may cause muscle strain.
- It may cause kidney and liver damage.

Not recommended.

DHEA

Banned.

DHEA is dehydroepiandrosterone: the major androgen hormone produced by the adrenal gland. Its effects result from its conversion to testosterone.

This natural hormone declines with age, but its importance (relative to other androgens produced elsewhere in the body) is uncertain. Due to its anabolic action, it could help performance. Of course, all anabolics are banned. Although a drug, it is unregulated and is sold in health food stores. Dosage, formulation, and quality are uncertain, as are long-term side effects.

Avoid.

Dimethyl Sulfoxide—DMSO

Not banned.

There is little evidence of any effectiveness. DMSO does have side effects.

Avoid.

Enzymes

Not banned.

See discussion under protein, athletic considerations, on page 63.

Not recommended.

Ephedrine

Banned

Some studies show performance improvements, others do not. Adverse side effects of ephedrine are legendary. (See herbs, below; stimulants, below; and *Some Diet History* in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.)

Avoid.

Equine Growth Hormone

Banned. Prescription.

Human growth hormone increases body mass and decreases body fat in humans. Equine growth hormone has a similar effect in horses.

According to the manufacturer's website,²¹ "Growth hormones are species-specific due to significant variation in their structure between species. Because primates, including humans, lack receptors for Equine Growth Hormone, the substance has no pharmacological action in these species. Equine Growth Hormone administered to

²¹ <http://www.bresagen.com.au/equigen>.

non-equine species will be recognized as a foreign protein and inactivated, while also presenting a risk of serious allergic reaction."

Avoid.

Erythropoietin (EPO)

Banned. Prescription.

See blood doping.

Avoid.

Food

Not banned.

See calories.

Endorsed.

Formoterol

Banned without governing body preregistration. Prescription.

See asthma medications.

Avoid without medical need.

Fenugreek

Not banned.

Fenugreek, an herb, is claimed to remedy colds, improve digestion, increase breast size, and control weight.

Studies have not shown any ergogenic benefit.

Not recommended.

Ginseng

Banned by some sports organizations including the NCAA.

Ginseng, an herb, is claimed to enhance recovery through improved lactate clearance.

Studies have not shown any ergogenic benefit.

Not recommended.

Glutamine

Not banned.

No effect on performance or weight loss.

Role in immune function, if any, is being investigated.

See discussion under protein, athletic considerations, on page 63.

Not recommended.

Glycerol

Not banned.

Glycerol, a three-carbon molecule, forms the backbone of triglycerides. It may also act to increase hydration, but so does a little extra salt in the diet.

Studies have had mixed results, mostly negative. Cramping and weight gain are side effects.

Not recommended.

Guarana

Not banned.

In a word, caffeine. Guarana is the dried paste of the crushed seeds of *Paullinia cupana*, a vine cultivated extensively in Brazil. Sounds exotic—it is about as exotic as Brazilian coffee beans. Its active ingredient is guaranine, another name for caffeine.

Would you buy an energy bar that contained caffeine? Maybe, maybe not. At least you would see the label, know what you were getting, and how much.

Not recommended.

Herbs and Exotic Compounds—“Adaptogens”

Some are banned.

With herbs, it is difficult to know exactly what you are ingesting. If they have an important pharmacological action for athletes, it is usually because they contain a known substance, perhaps banned.

Guarana is caffeine. Ma huang is ephedrine, a stimulant. These substances have been found in bishop’s tea, Brigham tea, chi powder, Energy Rise, Ephedra Exel, joint fir, Mexican tea, Mormon tea, popotillo, squaw tea, Super Charge, and Teamster’s Tea.

Many herbal products have diuretic actions—they increase the kidneys action to produce more urine. Herbs with diuretic actions include horsetail, lily of the valley, saw palmetto, sarsaparilla, and uva ursi.

Many popular energy bars and products contain these banned substances. Many products with the words Charge, Pep, Rocket, Thunder, or Turbo contain these substances.

Many herbs marketed for their ergogenic properties have no known studies demonstrating any effect. This applies, for example, to ginseng.

Not recommended.

Human Growth Hormone

Banned. Prescription.

Used for its anabolic effects. Growth hormone increases body mass and decreases body fat. It may not increase strength. Side effects include swelling, joint and muscle aches, diabetes, and when used with anabolic steroids, heart enlargement.

Avoid.

Hydroxymethylbutarate—HMB

Banned by some sports organizations including the NCAA.

Purported to spare protein, HMB is a proprietary product (sold by a company with a patent). There is little evidence of any effectiveness in trained athletes.

Several studies have found no help in strength training.

Decreased percent body fat in football players in a study funded by the manufacturer. Improved VO₂ max in one study.

Avoid.

Inosine

Not banned.

Inosine is a nucleic acid, and there is no evidence of an ergogenic effect. There are theoretical reasons why it may actually worsen performance.

Avoid.

Insulin

Not banned.

Used by body builders to decrease the breakdown of muscle cells. Side effects include low blood sugar and seizures.

Avoid unless diabetic.

Iron

Not banned.

Women with heavy periods are the group most likely to be deficient in iron. If not deficient in iron, there is no evidence that iron is ergogenic.

Read about iron in the free supplement to this book available through at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Read more about the ergogenic and ergolytic effects of minerals on page 126.

Consider if deficient.

Km

Not banned.

This proprietary potassium-mineral supplement was found to have no effect on performance in 30 subjects.

Not recommended.

Ma Huang

Banned.

Ma huang, a Chinese herb, is sometimes referred to as natural ephedrine. The herb contains a number of other alkaloids and metabolism is similar, but not identical to pure ephedrine.

Adverse side effects of ephedrine are legendary. (See herbs, above, and *Some Diet History* in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>).

Avoid.

MCTs

Not banned.

Medium-chain triglycerides—partially broken down fats—are thought to be an energy source that may spare glycogen.

Van Zyl reported in 1996 that medium-chain triglycerides could improve performance. Promotion and marketing of these products quickly followed. Efforts to reproduce these results failed.

Not recommended.

Melatonin

Banned by some sports organizations including the NCAA.

May help jet lag. A hormone produced by the pineal gland, melatonin is unregulated by the FDA and is sold in health food stores. Its potency is uncertain, contaminants potentially a problem, and its short- and long-term side effects are not known.

Not recommended.

Minerals

Not banned.

There is little evidence that iodine, magnesium, phosphorus, potassium, or selenium are likely to be lacking in most athletes' diets.

Calcium is not ergogenic. It is important for general health, and heavy sweating may increase losses. Many athletes' and non-athletes' bone health may benefit from supplemental calcium. Read more about calcium in the free supplement to this book available through at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Chromium and iron are discussed above and in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Phosphate may improve performance when taken several days before competition. It may act by buffering lactic acid, increasing glycolysis, and by increasing 2, 3 DPG—an enzyme that helps the blood release its oxygen to muscles. Bicarbonate may have some effect for events up to several minutes in duration by acting as a buffer for lactic acid. Both phosphate and bicarbonate may cause stomach upset and diarrhea.

Read more about phosphates under phosphorus, athletic considerations, in the free supplement to this book available at: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

Those exercising in the heat may become sodium deficient. Sodium may limit performance if deficient; it does not improve performance otherwise. Read more about sodium before, during, and after events beginning on page 14.

Read more about sodium, including the sodium content of selected foods and hyponatremia starting on page 162.

Some minerals in excess have been shown to *worsen* performance

Read more about the ergogenic and ergolytic effects of minerals on page 126.

Consider phosphates.

Modafinal

Banned. Prescription.

A stimulant. May benefit those with daytime sleepiness due to narcolepsy or other medical disorders. Long-term safety unknown.

Avoid.

Mucuna Prureins

Not banned.

Also known as cowitch or velvet beans. May contain L-dopa. Long-used for impotence and to increase libido.

Studies of effectiveness and toxicity are lacking.

Avoid.

Naproxen

Not banned.

See NSAIDs.

Consider.

Narcotics

Some banned. Some prescription.

Codeine, dextromethorphan, lomotil, and imodium are narcotics or derivatives that may not be banned.

They work by deadening pain.

Almost all narcotics worsen aerobic athletic performance because they depress the central nervous system. Often sedating,

they decreased focus. A loss of skills, among other side effects, may create safety issues.

Avoid.

NSAIDs

Not banned.

Aspirin, ibuprofen (Motrin), naproxen (Aleve), others.

Non-steroidal anti-inflammatory drugs reduce pain and inflammation. Some may have a helpful effect on blood flow. They have relatively few side effects; gastrointestinal upset the most common, dehydration-exacerbated kidney failure is potentially life-threatening.

Used by many athletes to treat musculoskeletal injuries or prevent muscle soreness. How many? In an anonymous survey of 444 athletes, including 106 professional athletes, 88.5% had used NSAIDs in the previous year.

Aspirin

In one study, lowered perceived exertion at 40% and 50% of peak power output in 19 subjects.

In another study, 650 mg one hour before exercise improved blood flow velocity.

Naproxen

A single dose of the over-the-counter product (Aleve) decreased exercise-related muscle soreness in 62 subjects.

Consider.

Nootropics

Not banned.

Stimulants including acephen, aniracetam, centrophenozone (meclofenoxate), cleregil, euclidan, glutamine, heptamol, 3-hydroxypyridine, ionol, nicametate, oxiracetam, pantogam, phenibut,

piracetam, pyritinol, sodium oxybutyrate, syndocarb (sidnocarb, mesocarb).

There are no valid scientific studies on these compounds, even though they are in widespread use in Europe.

Not recommended.

Oxygenated Water

Not banned.

See discussion in the hydration chapter on page 32.

Not recommended.

Pentoxiphylline (Trental)

Not banned. Prescription.

This prescription drug may work to increase blood flow, but there are no known studies of its effects in athletes. It is used by some to counteract the sludging and blood clotting effects of EPO.

Not recommended.

Peptide and Glycoprotein Hormones and Analogues

Banned. Prescription.

HCG (human chorionic gonadotropin) can work to make the testosterone:epitestosterone ratio normal, thereby masking steroid use. ACTH (adrenocorticotrophic hormone) has steroid-like effects. GH (growth hormone) has steroid-like effects. They all have potentially significant side effects.

Avoid.

Phosphates

Not banned.

See phosphorus, athletic considerations, in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Consider.

Pyruvate

Not banned.

Studies have not shown improvement in muscle strength, treadmill time to exhaustion, or maximal exercise.

Not recommended.

Ribose

Not banned.

In a manufacturer-supported study, sprint performance was improved in a few athletes. Most athletes showed no improvement.

Not recommended.

Salbutamol

Not banned. Prescription.

See asthma medications.

Avoid without medical need.

Sodium Bicarbonate

Not banned.

See bicarbonate.

Not recommend.

Sodium Dichloroacetate

Not banned.

No proven effects on performance.

Not recommended.

Sodium Phosphate

Not banned.

See phosphorus, athletic considerations, in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Consider.

Stimulants—Sympathomimetics

Some banned. Some prescription. Some illegal.

This class includes amphetamines, cocaine, adrenaline, and similar compounds: ephedrine, pseudoephedrine, isoetharine. Many asthma and decongestant medicines contain these substances.

Most athletes perform maximally without their use. They do not make you stronger. They may increase alertness, reduce fatigue, and increase competitiveness and hostility. They can “perk” you up, like a cup of coffee.

In low doses, they are probably not especially helpful; in high doses they are potentially dangerous, causing nervousness, anxiety, palpitations and heart irregularities, poor judgment, dependence, addiction and death.

Most of these compounds are banned. The only asthma medicines approved in this class are inhaled albuterol and terbutaline. If you have a medical need for these compounds and have a USOC waiver for their use, they may help you, and it is okay to use them.

Avoid without medical need.

Tribulus

Banned by some sports organizations including the NCAA.

This herb is marketed as a hormone enhancer.

It had no effect on testosterone or leutenizing hormone in one study. It did not change testosterone, but changed cortisol levels in another.

It did not change average power or VO₂, though time to completion of a 12.5-kilometer time trial was improved in one study.

It is premature to say whether tribulus works. If it does, it probably has anabolic-type side effects.

Tribulus supplements have been found to be contaminated with anabolic steroids.

Avoid.

Tyrosine

Not banned.

See discussion under protein, athletic considerations, on page 63.

Not recommended.

Vanadyl Sulfate

Not banned.

Vanadyl sulfate is purported to mimic the activity of insulin, but there have been no performance studies in humans.

Not recommended.

Vasodilators

Not banned. Prescription.

Nitroglycerin, for example, is reportedly used by some athletes near the end of a competition, not before or during. Studies are lacking. There are serious side effects.

Avoid.

Vitamins

Not banned.

If you eat a balanced diet, the usual advice is that you do not need any extra vitamins. A general multivitamin, costing about a dime a day, may be used as insurance. Anything additional is a waste

of money. Side effects from high doses do exist. Some vitamins taken in excess worsen performance.

“Vitamin B15”—pangamic acid—is an example of a substance sold to athletes with no recognized status in the scientific community and little to recommend it beyond hope and a placebo effect.

Read more about the ergogenic and ergolytic effects of vitamins on page 126.

Consider only in doses up to the RDA.

Water

The most important “ergogenic” aid, not banned, perfectly legal. Read more about hydration on page 27.

Endorsed.

Ergolytics

What We're Talking About

We have learned about ergogenic aids—substances that supposedly help improve performance. A great deal is written about materials or methods that may enhance exercise capacity or otherwise augment human performance.

Now let us concentrate on the things that work to undermine your performance, sometimes without your knowing it.

There is quite a long list of ergolytics: substances that worsen performance. Most athletes do not hear enough or think enough about these substances.

The list starts with nutrition: the energy sources you eat, the vitamins and minerals. It progresses to drugs, many of them medicines you might take under a doctor's orders. Then there are substances that you take thinking they will make you better, when in fact they make you worse! Do not be surprised to see some of the substances you saw listed under "Ergogenics" also listed here.

I do not mean the following listing to be comprehensive. I just want to get you thinking about what you put into your body or that what you do that may worsen your performance. I will discuss common, representative problem areas, and then briefly list other ergolytics in those areas.

Nutrition

Energy Sources

Too many calories. If your total intake of calories is too high, you are going to gain weight. Extra fat may help to protect from the cold and to float when you are swimming, but it worsens performance in most endurance aerobic events.

Wrong composition of calories. If you are an endurance aerobic athlete, performance comes from glycogen—a storage form of carbohydrate. If you use your glycogen daily, you have to replace it, and that means a diet high in carbohydrate. Fad low-carbohydrate diets—including the South Beach, Atkins, and 40–30–30 diets (40% carbohydrate, 30% fat, 30% protein) may be popular—but without the carbohydrate fuel, you cannot maintain high-energy output. A better aerobic endurance diet is one that contains 60% to 70% carbohydrate, 20% to 30% fat, and 10–15% protein.

Vitamins and Minerals

Sure, we all need vitamins and minerals—for our general health. Too much of some of them worsen performance. An energy bar or two on a ride, plus a multivitamin/multimineral tablet in the morning, add up to multiples of our RDAs for many of us.

No vitamins have been shown to improve performance; *eight* have been shown to worsen it or cause disease in excess. Although *six* minerals have been shown to possibly benefit human performance, *twelve* worsen performance or cause disease in excess.

The ergogenic and ergolytic potential of vitamins and minerals is discussed in *Vitamin & Mineral Supplements*, starting on page 126.

Street Drugs

Alcohol

Perhaps the most common ergolytic drug. Read about alcohol on page 93.

Other Common Ergolytic Street Drugs

- Tobacco, including smokeless tobacco.
- Marijuana.
- Cocaine.

Medical Drugs

Antihypertensives:

Diuretics, Beta-Blockers, Calcium-Channel Blockers

A sizable number of us take medicines for high blood pressure. Although exercise may reduce the need for these medicines in some people, high blood pressure is a big factor in heart attacks and strokes—diseases that account for almost half of all deaths. Doctors take hypertension seriously, but unfortunately, many of the drugs used for hypertension worsen high-level human performance.

Beta-blockers include Inderal (propranolol) and Tenormin (atenolol). If your blood pressure medicine ends in “alol,” it is probably a beta-blocker.

Beta-blockers are also used to treat migraine and other diseases.

In one study, a cyclist riding at a steady prescribed pace without Inderal in his system became exhausted after 79 minutes. At the same pace, with 80 milligrams of Inderal in his system, it took him only 23 minutes to become exhausted. His heart rate was reduced from 163 to 129 beats per minute. A similar effect was produced by 100 milligrams of Tenormin. Many other studies have shown that beta-blockers worsen athletic performance.

According to *Consumer Reports on Health*, “Beta-blockers reduce the body’s ability to regulate temperature, so drink up before, during, and after workouts; exercise in the cooler hours... and consider scaling back workouts in really hot weather.”

Diuretics and some calcium channel blockers may also worsen aerobic athletic performance.

Fortunately, most medically prescribed ergolytic drugs have substitutes that treat the medical problem without the ergolytic effect. Be sure to ask your physician whether prescribed drugs worsen performance and whether there is a substitute. For example, in the case of hypertension, an angiotensin-converting enzyme (ACE) inhibitor may be a better choice.

Other Common Ergolytic Medical Drugs

- *Antacids.* The over-the-counter availability of cimetidine (Tagamet) and other so-called H₂ blockers has helped many with acid problems. However, Tagamet is also an anti-androgen—it lowers testosterone levels, and so reduces muscle mass, reduces the red blood cell count, and worsens performance.
- *Antibiotics.* Their ergolytic effects are probably overstated. I recommend taking antibiotics if a doctor feels they are needed, rather than suffering through an illness without them.
- *Antidepressants.* Some are associated with ergolytic effects.
- *Oral antifungals*, including ketoconazole, now commonly prescribed for toenail fungus, can be ergolytic.
- *Antihistamines* can help allergies or other problems that worsen performance, but in some individuals the drugs themselves can reduce performance.
- *Eye drops* used for glaucoma, including timolol, are beta-blockers, which can be absorbed into the body. Studies have shown that they can worsen performance.
- *Sleeping pills.* May have hangover effects, which worsen performance.
- *Cough suppressants*, commonly codeine or other narcotic derivatives. Often sedating. Decreased focus, loss of skills, and safety may be resultant problems.

So-Called Ergogenics

Caffeine

Many studies have shown that caffeine can improve performance, but it can worsen it as well. Interrupted sleep, inadequate sleep, anxiety, and headaches are all common side effects and can worsen performance. Those dependent on caffeine are also

subject to withdrawal symptoms, which may include fatigue, personality changes, and an inability to perform workouts.

Other Potentially Ergolytic Ergogenics

- *Erythropoietin (EPO)*. Sure, this blood-augmenting hormone can improve human performance. However, disability or death due to thickening of the blood and blood clots, causing stroke or heart attack, will slow you down in a hurry.
- *Anti-inflammatories*. Although many athletes find that a couple tablets of aspirin or ibuprofen (Advil, Motrin) can be helpful before a ride, occasional side effects are a potential problem. A possible worsening of performance has been reported in a minority of studies.
- *Phosphate sodium*. This substance is one of the few that has been shown to improve performance in many studies. However, gastrointestinal side effects, including cramping and fluid retention due to the sodium component, can worsen performance too.
- *Bicarbonate*. Lactate buffering with bicarbonate of soda has been practiced for years. However, many athletes suffer cramping and diarrhea, which may make performing even a 1-minute kilometer bicycle race impossible.

Vitamin & Mineral Supplements

North American and European athletes tend to have relatively few nutritional deficiencies compared with Third World athletes, who often have major nutritional intake deficiencies.

Most endurance aerobic athletes eat more than their sedentary counterparts do. Increased vitamin and mineral needs are generally met by this increased caloric intake. However, carbohydrate needs are often suboptimal.

If you eat a balanced diet, the usual advice is that you do not need any extra vitamins.

Not all of us eat a varied and optimally healthful diet. Sometimes it is because we are too busy and rely on fast food. Sometimes it is because we have food intolerances; for example, lactose intolerance of milk products. Sometimes it is because we choose to avoid foods because of religious or other beliefs; for example, we are vegetarian. Sometimes it is because we are fussy or odd eaters; for example, we hate vegetables or we prefer to eat Cheerios three times a day. Sometimes it is because we starve ourselves to keep thin.

Supplements can help optimize health and athletic performance in those whose diets are imperfect.

A general multivitamin, costing about a dime a day, may be used as insurance. Anything additional is generally a waste of money.

Side effects from high doses do exist. For example, most multivitamin supplements now carry the warning: “Long-term intake of high levels of vitamin A (other than from beta carotene) may weaken the bones in older adults. Consult your physician before taking another vitamin A-containing supplement with this product.”

Some vitamins taken in excess worsen performance.

In athletes without vitamin and mineral deficiencies, nutritional supplements do not exhibit an ergogenic effect.

For a specific discussion of an individual vitamins or minerals, see the chapter on that specific vitamin or mineral.

Increased Performance

The Claims—Purported Benefits

All the vitamins, with the exception of vitamin K and biotin, have been claimed to improve performance.

“Vitamin B15”—pangamic acid—is an example of a substance sold to athletes with no recognized status in the scientific community and little to recommend it beyond hope and a placebo effect.

For theoretical reasons, sport scientists have considered that six trace minerals may possibly have a role in athletic performance: chromium, copper, iron, phosphorus, selenium, and zinc. Only iron, phosphorus, and zinc have been shown in studies to have any ergogenic potential. Read more about iron and phosphorus in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Possible Benefit of Vitamin-Mineral Supplements

- *Pantothenic acid* reduced oxygen use for a given workload in a group of runners in one study. Others studies show no benefit.
- *Antioxidant vitamins* are vitamins C, E, and beta-carotene (a precursor form of vitamin A). Overall, they have not been shown to improve performance. For more information about antioxidants, see page 25.
- *Vitamin C* has been shown to improve performance in a few studies but has also been shown not to improve performance in the majority of studies. The best-designed studies tend to show no effect.

- *Vitamin E* has been shown to improve performance in a couple of studies. Many more show no benefit.
- *Iron* has been shown to improve performance in athletes who are iron-deficient and anemic. In the absence of anemia, it has not improved performance.
- *Phosphorus* in the form of phosphates has been shown in some studies to improve performance. Other studies show no benefit.
- *Zinc* has been shown to improve some measures of muscle performance in one study. Other studies show no benefit.
- Studies have specifically failed to demonstrate performance benefit for Vitamins A, D, B1, B2, B3, B6, B12, biotin, folic acid, copper, and selenium.

Decreased Performance

Many athletes take out “extra insurance” and consume large doses of almost all known vitamins and minerals— “just in case.”

One problem associated with supplements is that an excess of one vitamin or mineral may interact with and affect the absorption or metabolism of another vitamin or mineral. Because of such an interaction, a deficiency may result even though the other vitamin or mineral is present in “normal” amounts. Balance is sometimes more important than quantity.

The vast majority of studies have not found any improvements in exercise performance with individual or combination vitamins or minerals.

Many studies have shown that supplements can *decrease* performance.

This is particularly true for vitamin B3 (niacin) and vitamin B6 (pyridoxine) whose ergolytic effects are via direct energy-related mechanisms.

For almost all vitamins and minerals, doses beyond the RDA cause side effects that not only can decrease performance, but also can cause disability or death.

- *Vitamin A* excess can cause headache, loss of appetite, vomiting, hair loss, itching, bone pain, and kidney and liver damage. Long-term use is associated with osteoporosis and hip fractures.
- *Vitamin B₃ (niacin)* prevents the release of fatty acids. This can adversely affect endurance performance. Excess B₃ can release histamine, causing flushing, itching, asthma, and gastrointestinal problems. Vitamin B₃ can cause gout, diabetes, and liver damage.
- *Vitamin B₆ (pyridoxine)* can cause depletion of glycogen stores. An excess can cause neurologic problems, including clumsiness and gait disturbance. It can interfere with the action of prescribed medicines.
- *Folic acid* excess can camouflage vitamin B₁₂ deficiency, allowing neurologic problems associated with B₁₂ deficiency to progress unchecked.
- *Vitamin C* excess can cause decreased levels of vitamin B₁₂, increase estrogen levels, and cause diarrhea and kidney stones.
- *Vitamin D* excess can cause increased calcium in the blood and kidney stones.
- *Vitamin E* excess can cause malaise, gastrointestinal problems, blurred vision, headache, bleeding tendencies, and possibly hypertension.
- *Vitamin K* excess can interfere with the action of prescribed medicines and cause jaundice in a newborn infant.
- *Calcium* excess can cause kidney and neurologic disease.
- *Chromium* excess can cause kidney failure and lung cancer.
- *Copper* excess can cause liver and kidney disease, anemia, and mental deterioration.

- *Fluoride* excess can cause mottled teeth, gastrointestinal problems, muscle contractions, and heart disease.
- *Iron* excess can cause liver failure; diabetes; testicular atrophy; arthritis; and heart, skin and neurologic disease.
- *Magnesium* excess can cause tremor, spasm, rapid heart rate, and high blood pressure.
- *Manganese* excess can cause headaches, weakness, cramps, impotence, Parkinson-like symptoms, and psychosis.
- *Molybdenum* excess can cause gout.
- *Selenium* excess can cause hair loss, fingernail abnormalities, emotional problems, and fatigue.
- *Sodium* excess can cause fluid retention and high blood pressure. Weight gain can limit performance in weight-dependant sports.
- *Zinc* excess can cause stomach ulcers, pancreatitis, lethargy, anemia, fever, nausea, and lung problems. Zinc excess reduces “good” cholesterol (HDL) and increases “bad” cholesterol (LDL). It is also associated with impaired immune function and decreased copper absorption.

Conclusion

The functions, increased requirements, and ergogenic and ergolytic effects of vitamins and minerals are summarized in Table 26, below.

In athletes without nutritional deficiencies, nutritional supplements do not exhibit an ergogenic effect.

Ideally, get the recommended daily allowance from food. If your diet is not ideal and you wish to supplement, do so only up to the RDA.

Megadoses not only may fail to improve performance but also may be toxic.

Vitamin & Mineral Supplement Summary Tables

Table 26 and Table 27, below, summarize the functions, increased requirements, and ergogenic and ergolytic effects of vitamins and minerals.

Function

The accepted scientific actions of the nutrient are listed in this column.

Increased Needs in Athletes

Some nutrient needs are known to increase with athletic activity. Supplements are not generally required because of increased needs. Most increased needs are met by increased food consumption.

If well-established increased needs are known, they will be listed in this column.

Ergogenic Benefit?

There are two issues:

1. Is a deficiency of the nutrient associated with impaired performance?
2. Will extra, or supplemental, nutrient enhance performance?

It is mostly the latter that we are concerned with in these columns. For example, iron deficiency may worsen performance. If not deficient, is iron supplementation ergogenic?

A threshold value may exist for optimal performance. It may be that a certain dose prevents a deficiency state but that supplementation only up to a certain level improves performance.

Ergogenic Mechanism

Whether or not actual benefit has been shown, claims of how the nutrient may improve performance are listed in this column.

Evidence of Benefit

Studies may have been performed to assess performance loss that accompanies vitamin or mineral deficiency, or performance improvement with supplements. Studies may or may not have been performed on athletes.

Performance on a bicycle is different from performance in other sports. The beneficial effects, if any, in one sport, may not be applicable to bicycling. Studies have usually been performed on college-aged men and women, so findings are not necessarily applicable to master or junior athletes.

The results of studies are noted in this column. If a study shows a positive effect, it is noted as *Yes*. If a study shows no effect, it is noted as *No*.

Evidence of Harm

Some nutrients have toxic side effects, and some may worsen performance. Where such information is available, it is summarized in the table.

Vitamins: Athletic Benefit & Harm

Vitamin	Functions	Increased Needs in Athletes	Ergogenic Benefit?		
			Purported Mechanism	Evidence of Benefit	Evidence of Harm
A	Antioxidant		↑ Tissue repair	No	Yes
B1 (thiamin)	Carbohydrate metabolism, co-enzyme	Y	↑ Endurance, performance, ↓ fatigue	No	Non-toxic
B2 (riboflavin)	Aerobic metabolism, co- enzyme	Y	↑ Aerobic performance	No	Non-toxic
B3 (niacin)	Aerobic metabolism, co- enzyme	Y	↑ Energy, performance	No	Yes
B5 (pantothenic Acid)	Fatty acid metabolism, co- enzyme		↑ Aerobic performance	No:Yes::4:1	Non-toxic
B6 (pyridoxine)	Glucose and hemoglobin production, metabolism	Y	↑ Endurance	No	Yes
Folic acid (folate)	Nucleic acid and RBC production		↑ Endurance, performance, ↓ fatigue	No	Yes
B12 (cobalamin)	RBC production	Y	↑ Endurance, performance, ↓ fatigue	No	Non-toxic
Biotin	Glycogen formation, co- enzyme		None	No	Unknown
C	Antioxidant, collagen		↑ Tissue repair, performance, ↓ colds	No:Yes::2:1	Yes
D	Bone metabolism	Y	↑ Bone formation	No	Yes
E	Antioxidant	Y	↑ Tissue repair	No:Yes:: 4:1	Yes
K	Clotting		None		Yes

Table 26. Ergogenic and ergolytic potential of vitamins. Read the text preceding this table. “No:Yes::4:1” means 4 studies show no benefit for every 1 study that shows benefit.

Minerals: Athletic Benefit & Harm

Mineral	Functions	Increased Need in Athletes	Ergogenic Benefit?		
			Purported Mechanism	Evidence of Benefit	Evidence of Harm
Calcium	Bone building, muscle contraction	Y	None		Yes
Chloride	Electrolyte, digestion, blood pressure.	Y	None		
Chromium	Immune function, potentiates insulin	Y	↑ Muscle formation, ↓ fatigue	?	Yes
Copper	RBC formation, immune system		↑ Aerobic performance	No	Yes
Fluoride	Tooth enamel, bones		None		Yes
Iodine	Thyroid		None		
Iron	Blood formation, immune function.	Y	↑ Performance, ↓ fatigue	No ¹	Yes
Magnesium	Electrolyte, muscle contraction, nerve action, calcium metabolism, enzyme cofactor		None		Yes
Manganese	Bone, cell reproduction, enzyme action		None		Yes
Molybdenum	Enzyme action		None		Yes
Nickel	Immune function, brain development, DNA synthesis				
Phosphorus	Electrolyte, bone formation, cell energy		As phosphate, may buffer acid	No:Yes::3:2	Yes
Potassium	Electrolyte, nerve transmission, blood pressure, muscle contraction		None		
Selenium	Antioxidant, activates vitamin E	Y	↑ Tissue repair, ↓ fatigue	No	Yes
Silicon	Enzyme action, connective tissue				
Sodium	Electrolyte, waste removal.	Y	None	No ¹	Yes
Sulfur	Protein synthesis, collagen, bone and ligament structure				
Tin	Enzyme function				
Vanadium	Circulation, sugar metabolism				
Zinc	Metabolism, tissue repair	Y	↑ Anaerobic performance, ↓ fatigue	No:Yes::3:1	Yes

Table 27. Ergogenic and ergolytic potential of minerals. Read the text preceding this table. ¹Unless deficient. “No:Yes::3:2” means 3 studies show no benefit for every 2 studies that shows benefit.

Part 5:

Promotion & Quackery

Introduction

Athletes Are Targeted

It is often said that Americans have the most expensive urine in the world.

Vitamin and mineral supplement sales are big business. Many athletes take scores of pills daily. Companies try to distinguish themselves from others by claiming that their formulations are superior. As noted throughout this book, there is very little evidence that *any* supplements are worth it.

Food is likely to contain yet unknown important substances. Vitamin and mineral pills may not meet our yet unknown needs.

Mainstream scientists do not recognize any significant difference between natural and synthetic vitamins or between different formulations. The cost of such supplements can be very large and is not worth it.

Most of us get all the vitamins and minerals we need with a good diet. If you want to be safe, you can take (1) a daily multivitamin/multimineral such as Centrum or a major-chain grocery store brand and (2) a calcium supplement if you do not consume at least 16 ounces or more of milk or yogurt and other calcium-rich foods daily. Centrum costs a few dollars per month at the local grocery store or pharmacy. Spend more money than that on vitamins, and you are probably wasting your money. Even worse, you may experience side effects and decreased performance.

“Fad Compounds” & Ergogenics

Some substances called vitamins are not recognized as such by the scientific community. The promotion of these substances more often benefits the seller’s pocketbook than the performance of the athlete who purchases them. “Vitamin B₁₅”—pangamic acid—is an

example of a substance sold to athletes with no recognized status in the scientific community and little to recommend it beyond hope and a placebo effect.

Quasi-medical sources will suggest that certain herbs, spices, or other substances may be helpful. Sometimes alternative nutritional compounds contain naturally occurring drugs that do have some action. These effects are not always beneficial, and sometimes they are harmful. These compounds are often illegal for athletic use.

Some of these compounds are discussed more fully in the chapter on ergogenics on page 109 and in the chapter on ergolytics on page 124.

If you are still not convinced, think of it this way: There is enough known nutritional information on which to concentrate your time, effort, and money. You need not invest in the unknown.

For more information about how to evaluate nutritional claims, read on.

Ergogenic Quackery

Maxxta Makes You Fasta

What We're Talking About

High-carbohydrate or high-fat diet? Power Bars or PR? Creatine? Antioxidants? Laetrile? Chelated vitamins and minerals? Melatonin? Yohimbe? DHEA? Breathe-Right Nasal Strips? Echinacea? Garlic? Ma huang? Ginseng? *Siberian* ginseng?

The headline SCREAMS “Improved performance with the new wonder miracle supplement—*Maxxta*.”

One little seed, raising the possibility of improved performance, is planted in your brain.

Will it make you faster? Does the fact that the current world champion uses it mean that it really works? Does the fact that your friend uses it—and says it works—mean that you should try it?

Snake oil was the magical elixir in times not long past. Moreover, regardless of the age, it seems there is no shortage of athletes or ordinary folk looking for the magic pill or potion to make them younger, go faster, be thinner, or cure the incurable. How can you know what is real and what is a sham?

Be a Skeptic

Perhaps the first requirement is a healthy dose of skepticism. A multitude of products are claimed to improve performance, retard aging, or make one go faster. However, very few substances have ever been shown to work at all.

The personal testimony of others may be interesting, but it is no secret that such declarations are often without merit. The profit motive is frequently present. Even the most skilled observer or scientific mind is often subconsciously influenced into thinking that something is happening when the substance is actually bogus.

When I started time trialing, racing 10 miles against the clock, I read that caffeine might help. I did a dozen time trials my first year. I was positive that I rode faster when I got that caffeine boost from my secret potion—coffee yogurt. Only years later did I learn that the company that produced the yogurt used coffee-flavored extract and that there was no caffeine at all in my magic go-faster food!

Science Is Required

Scientific study is the way to go. The word *science* is frightening to some and makes others suspicious. However, it is really quite simple: in the scientific method, a question is asked and an experiment is performed. Enough people participate for long enough to enable some conclusions to be drawn.

For example, one simply looks at what happens to two groups, one taking the “good stuff” being tested, the other taking a similar looking or tasting stuff—a placebo, without active ingredients.

Because believing in something influences not only those taking the product but also those conducting the experiment, it is important that neither group knows who’s getting what until the results are in, the “code” of the experiment broken, and the results analyzed.

For details on what makes a good study see page 135.

Science Has Limitations

The problem is more complicated, however. Although some fear “science,” others endorse it too readily. “Science” is fallible.

“Assumptions can be dangerous, especially in science. They usually start as the most plausible or comfortable interpretation of the available facts. But when their truth cannot be immediately tested and their flaws are not obvious, assumptions often graduate to articles of faith, and new observations are forced to fit them.”²²

²² John S. Mattick, *Scientific American*, October, 2004.

Publication and Other Biases

Although the scientific method is the way to go, you have to look at how the real world operates before blindly accepting scientific results.

Take 10 researchers looking into whether or not Maxxta makes you faster. Suppose Maxxta is a new substance, not well studied. There are no reports yet in the scientific community about it. In fact, it is doubtful whether anyone cares about it at all. Of the 10 researchers, 9 look at the product and find no reason to pursue their study. Early studies either show no effect or just do not seem promising enough to warrant more research.

No one, not the scientific nor the lay press, is interested in reporting that something unknown does not work. Only positive findings on new products make their way into the press.

However, one of the researchers does see some positive effect. This researcher gets excited. This researcher contacts a product-development company, and the stuff is marketed. The public relations people are called in. The next thing you know, *Runner’s World*, *Bicycling*, *Men’s Health*, and *New Woman* publish articles, and people are talking. The results look impressive.

Athletes are charged up about the whole idea. Members of the national team get wind of the research and wonder whether they should be taking Maxxta. The national coaches and physiologists wonder too, and they decide they had better try it.

The manufacturer says fine; let me send you some product to try. The manufacturer notes in its advertising that the national team is using Maxxta. This gets everyone else thinking they had better use it too. Moreover, since Maxxta costs a lot, you had better believe you are getting something for your money.

A couple of years go by, and Maxxta is the rage—everybody is buying it. Some of the original 10 researchers scratch their heads and remember that they found no effect. Most of them are respected

PhDs and MDs. A few review their earlier efforts and restudy whether Maxxta works. A couple of them report their negative findings at the next poster session of the American College of Sports Medicine.

Runner's World and *Bicycling* get hold of the negative studies. Now they are interested, because now that everyone thinks Maxxta works, a negative study is news. By now, four years have passed.

Maxxta does not really work. Nine out of the 10 original researchers found no effect. The one who found a little effect and sold the product might have been an honest researcher, but honestly came up with fluky results. (Or not. Read more about product promotion on page 142.) The magazines did their job and published the original positive information because it *was* news.

So what? Somebody made a profit. Some new product will come along to replace Maxxta.

The bottom line is that you do need good scientific research to establish whether something works. However, you also need to be cautious. Understand that selection bias in reporting and publishing means what works is published, and what doesn't isn't—until it is news to say otherwise.

What Makes a Good Study?

The great enemy of the truth is very often not the lie—deliberate, contrived and dishonest—but the myth—persistent, persuasive and unrealistic.

John F. Kennedy

Claims may be made with no evidence for financial or other gain. Claims may be based on a theory, animal studies, or poor-quality human studies.

Let us dismiss claims based on theory or animal studies as being unlikely to be useful for athletes.

Q: If claims are made based on human studies, how can we evaluate them?

A: Look at the group studied, identify and evaluate the methods used in order to understand how the study was done, locate potential study limitations, place the study within the context of already known or published information, and draw your conclusions.

The study of populations, the use of mathematics to evaluate results, and reasoning are helpful in evaluating studies. If you are seriously interested in developing an expertise in evaluating studies, consider courses in epidemiology, statistics, and logic.

Why do you need logic? Consider: Consumption of fruits and vegetables is associated with a decrease in the incidence of cancer. Fruits and vegetables have antioxidants. Therefore taking antioxidants will reduce cancer. Don't see the problem? (It is that there might be other substances other than antioxidants in fruits and vegetables that account for their cancer-reducing association.)

How about: A study of height and caloric consumption found that taller people eat more. If you conclude: To grow taller, eat more, a logic course will help you not only evaluate studies better, it will help you get through life.

Where Did You Get the Information?

Information from lay publications, advertising, fellow athletes, endorsements, or coaches may be biased. Read more about this on page 142.

Published results of studies should not be taken at face value alone. Peer-reviewed studies are of greater value than self-funded self-published studies. Abstracts or reports are of lower value.

Smell Test

Every study method and design has limitations. Irrespective of the methods used, the results should make sense to you. If the author's results do not make sense, be cautious about accepting them at face value.

Study Design

Suppose you have two treatments to compare. They might be two diets, two forms of exercise, or two pieces of equipment. How should you design your study to obtain a valid comparison of the two treatments?

Common sense probably tells you, correctly, to give the treatments to two groups of comparable subjects and see which group does better.

It is simple, yet it can be complicated.

Give more weight to studies that are prospective, controlled, double-blinded, and include large numbers of subjects.

Prospective, Double-Blinded, Randomized, Controlled Trials

Done well, these studies generally provide a high level of evidence.

This design reduces the effects of confounding and bias more than other designs.

Prospective

A study in which subjects are enrolled and then followed forward in time. This is important in studies on ergogenics, therapy, prognosis, or harm. Retrospective studies make hidden biases likely.

Blinded (Masked)

Blinded means blind with respect to treatment.

In a *single-blind study*, subjects do not know what treatment they are receiving. This insures their responses will not be affected by prior expectations and that subsequent behavior will not be affected by knowledge of the treatment. In some rare instances, *single blind* refers to situations where subjects know their treatments and only the person evaluating them is blinded.

In a *double-blind study*, subjects and anyone who has contact with them or makes judgments about them is blinded to the assignment of treatments. This insures subjective judgments will not be affected by knowledge of a subject's treatment.

In *triple blinding*, the analyst or statistician is given the data with uninformative treatment labels such as A and B and their identities are not revealed until the analyses are completed.

Blinding improves the quality of a study. For example: A researcher studying bone density in cyclists and attempting to show that cyclists had low bone density discarded the results of one cyclist who had high bone density, after collecting her data, on the basis of the subject having been an ex-runner. If this subject was to be excluded, she should have been excluded before her bone density results were known.

In nutrition, medicine and science, when a new diet, drug, or technique is introduced, initial studies may not be blinded. Treatment effects diminish as the studies go from unblinded to blind to double-blind.

Randomized

Randomized means that subjects are assigned to groups at random, so that each subject's treatment is a matter of chance, like flipping a coin. This reduces both conscious and unconscious bias. It helps insure that the groups will be similar not only with respect to factors that are known to effect the outcome, but also to unanticipated or even unknown factors that might influence the outcome had purposeful assignments been used.

When significant differences exist between groups, it not only calls into question the randomization process, but the rest of the study as well.

Subjects in randomized controlled trials may be selected with bias. They may be different from the general population to which the conclusions of the study may be directed. Results may not be applicable to subjects and settings different from those in the study.

Asking male endurance cyclists to volunteer for bone density tests to determine the risk of osteoporosis in male endurance cyclists may sound reasonable on the face of it. This process may not result in a group representative of male endurance cyclists. The volunteer group may be made up of riders who have reason to worry about their bones and so volunteer to find out their status.

Take heed when you see a note at the end of research articles that states: "These results may be due to the particular type of subjects seen in this setting, and may not be applicable to other groups."

Controlled

Placebo controlled means that the study involves two treatments—the treatment under investigation and an ineffective control (a placebo, a "sugar pill") to which the new treatment is compared. Both groups must be treated the same—except for administration of the treatment.

If the two groups have different outcomes, then there is evidence that it is due to the single treatment by which the two groups differ.

A control group may seem like a waste of resources. However, a treatment is not just taking some substance or following a particular exercise program. Placebo effects are often strong, and include: contact with investigators, heightened awareness of the problem, and any changes treatments might produce.

Be alert to: "Subjects were used as their own controls."

Subjects can and often should be used as their own controls if all treatments can be administered simultaneously (for example, creams A and B randomly assigned to the right and left arms).

"Subjects as their own controls" often means testing a subject, administering a treatment, and testing the subject again. The difference in measurements may be called the treatment effect.

This can be disastrous. Changes due to the treatment are confounded with changes that occur over time. We cannot know without a control group.

To appreciate the danger of a lack of a control group, look at the results of the control group when you read about placebo-controlled trials.

Systematic Reviews & Meta-Analyses

A systematic review is a comprehensive examination of a topic. Prior studies are identified, evaluated, and summarized according to a specific methodology.

A meta-analysis is a study method in which the results of similar studies of a particular problem or issue are combined and analyzed mathematically in order to give a combined “average” of individual studies. This analysis increases the ability to detect statistically significant differences.

Pitfalls exist with both of these methods. Authors may include only studies that support their view. Meta-analysis assumes all the studies included are of equal quality, which is rarely true. Results of different studies often do not specifically agree, making it difficult to average the different studies. The number of subjects in some studies is not large enough to provide a critical conclusion. Studies with positive conclusions tend to be published more than ones that have negative results: Weakly positive studies may be published and available, strong negative studies may not.

Cohort Studies

Subjects presenting a certain condition or receiving a treatment are followed forward over a period of time and compared with subjects not affected with the condition or receiving treatment.

A common pitfall: The two groups differ in other ways.

Case-Control Studies

Those with a certain condition or treatment are compared with those without, retrospectively.

Case-control studies begin with an outcome and go back in time to determine if the outcome is associated with any factor(s).

Biases are common. For example, biases related to either the selection of controls or the ability for cases and controls to recall information.

Case Series & Case Reports

Descriptive, these series and reports do not or cannot statistically evaluate a relationship.

They usually communicate or describe a new situation, problem, condition, or rare phenomena.

Other Factors to Consider

A Priori: Questions Asked Ahead of Time

The best studies have a formed, clearly stated primary question and primary outcome measure. What do we wish to test or learn?

Be skeptical of results that are not part of a study’s original questions. When many results are analyzed, some will appear to be statistically significant by chance. These results should not be given the same weight as the results of the primary question.

“Data snooping” results may be important, but they may be an attempt to justify a study that did not work out as hoped or intended.

Such results should be tested in follow-up studies.

Researcher Agenda

Has the researcher set out to prove a theory? Many researchers keep testing and looking for data to support their point of view.

For example, a researcher is interested in proving that a new cycling shoe will improve performance. In the first study, time trial times for 5 miles are compared between the new shoe and a standard shoe. No difference. In the second study, heart rate is examined. No difference.... In the tenth study, lactate levels are examined. A small, but statistical difference is... published and hyped.

Dropouts

Were all the subjects who entered the study accounted for at its conclusion? Were there dropouts because of adverse effects? Sodium bicarbonate may improve time trial performance, but if half the athletes who take it drop out because of diarrhea, you do not want to look at just finishers in drawing conclusions.

Length of Study

Was the study done long enough to show the effect, or uncover side effects? A new diet book may help reader lose weight after 8 weeks, but where are they after 16 weeks? 1 year?

Neutral-Party Funding

Biases in research, publication, and promotion related to private-party funding are notorious and legion. This is discussed throughout this section. For an example, read about Endurox R4 on page 154.

Power (Sufficient Numbers)

Were there enough study subjects to show an effect? Studies in athletes are notorious for having a dozen or fewer subjects.

Small studies with discrete outcomes may show results with no treatment effect. Consider an eight-subject study with just one discrete outcome measure. Suppose the outcome, like tossing a coin, is random.

With just eight athletes, there is often a reasonable chance of an “unexpected” result by chance.

If you toss a coin eight times, you might expect three, four, or five heads or tails. Almost a third (29%) of the time, heads or tails will occur more than expected.

Real-World, as well as Statistical Significance

Just because something is significant, it does not mean it is important. A one pound-lighter bicycle (at a cost of an extra \$1,000) may reduce the time it takes to climb a six-mile hill by 30 seconds over an hour, or 5 seconds over every 10 minutes it takes to climb a one-mile hill. If you are a recreational rider and never climb for more than 10 continuous minutes, does this have any real-world importance to you?

Junk Science

The Food and Nutrition Science Alliance (FANSA) represents members of the American Dietetic Association, American Institute of Nutrition, American Society for Clinical Nutrition, and Institute of Food Technologists.

Food and nutritional quackery is so common that FANSA has published 10 warning signs of bad or junk science.

The following are FANSA’s 10 Red Flags of Junk Science:

1. Recommendations that promise a quick fix.
2. Dire warnings of danger from a single product or regimen.
3. Claims that sound too good to be true.
4. Simplistic conclusions drawn from a complex study.
5. Recommendations based on a single study.
6. Dramatic statements that are refuted by reputable scientific organizations.
7. Lists of “good” and “bad” foods.
8. Recommendations made to help sell a product.
9. Recommendations based on studies published without review.
10. Recommendations from studies that ignore differences among individuals or groups.

Supplement Caveats

Supplements are not regulated in the same ways drugs are. Keep in mind that:

- Supplements for sale to the public may not produce the same effects and may not be the same as the special extracts used in scientific studies.
- There is often a lack of quality control.
- Studies are usually sponsored by manufacturer.
- Studies may be of poor design.

- No regulatory approval is required.
- Optimism reigns, advertising copy often implies 100% effectiveness for everyone.
- Advertising copy neglects to mention drawbacks or difficulties.
- Advertising copy neglects to mention other alternatives. For more on this subject see *Product Promotion* on page 142.

FDA Approval

Lack of approval means research results have not been evaluated by the FDA, and that there has been no testing for safety or effectiveness by FDA.

Even if worthless, effectiveness is only relevant for drugs, not food products. Product must be proved unsafe to be removed from market.

Doses may vary and there may be a lack of quality control. For example, studies have shown that even though the product labeling is the same, ginseng content in supplements may vary by factor of 10, from same manufacturer.

Quackery Flags Examples

The following advertisements demonstrate how FANSA's warnings might be heeded.

The author, in highlighting these products, does not imply that the product is or is not effective.

The first example, Figure 15, is for a Chinese diet tea. It is so outrageous that few athletes are likely to accept the advertisement at face value.

Red flags for the Chinese tea product include:

- Claim that sounds too good to be true: Losing more than six pounds per week.
- Promise of a quick fix.
- Secret ingredients.

- Use of key words: for example, “natural.”
- No independent review.
- Wants money.

1 Lost 64lbs in 10 weeks!

*After 10 weeks weight loss was 64 lbs. 100% guaranteed!

98¢



Chinoso Diet Tea...

POWERFUL HERBAL FORMULA SHEDS POUND AFTER POUND!

YOU'LL LOVE IT!

You eat your favorite foods - but STILL lose weight!

Our Chinoso Diet Tea has been clinically **tested on 103 patients**. All participants lost between 10 lbs and reach their goal weight. **100% guaranteed** to give you **significant amounts of weight loss** in **10 weeks!**

10 WEEKS TO GO TO YOUR IDEAL WEIGHT! MONEY IN FULL

- Eliminates an amazing 91% of absorbed sugar
- Prevents 34% of fat absorption
- Your metabolism rate increases 100%
- Powerful natural **burns** before you eat
- **100% guaranteed** to give you **significant amounts of weight loss** in **10 weeks!**

Chinoso Diet Tea is a powerful natural formula that **burns** before you eat. It **eliminates 91% of absorbed sugar** and **prevents 34% of fat absorption**. This means you can eat your favorite foods and still lose weight. **100% guaranteed** to give you **significant amounts of weight loss** in **10 weeks!**

4 Week course
You'll lose up to **\$288**

8 Week course
You'll lose up to **\$39.90**

12 Week course
You'll lose up to **\$49.85**

SAVE \$10.00
SAVE \$25.00

IMPORTANT: Chinoso Diet Tea is a natural herb and safe for everyone. No side effects.

Remember - the more Chinoso Diet Tea you drink... the more weight you lose!

IMPORTANT: Please do **NOT** ship and handling to any nearby countries.

SEND COUPON TO:
AEBION, INC.
1001 LAKELAND AVE.
BOHEMIA, NY 11716

Aebion

1-800-827-3681
1-800-827-3681
1-800-827-3681

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Figure 15. Nutritional quackery flags are described in the text.

The second and third examples, Figure 16 and Figure 17, are more believable, in part, because of familiarity, because athletes and coaches have embraced these products. An endorsement, however, means only that the athlete or coach was paid for their statement.

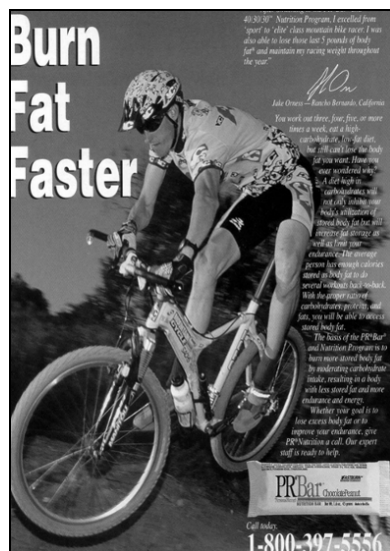


Figure 16. Nutritional quackery flags are described in the text.

Red flags for the PRBar product advertised in Figure 16 include:

- Claim to promote product.
- No scientific proof.
- Dramatic claim, repudiated by science.
- Other factors causing improvement?
- Multi-level marketing/pyramid.

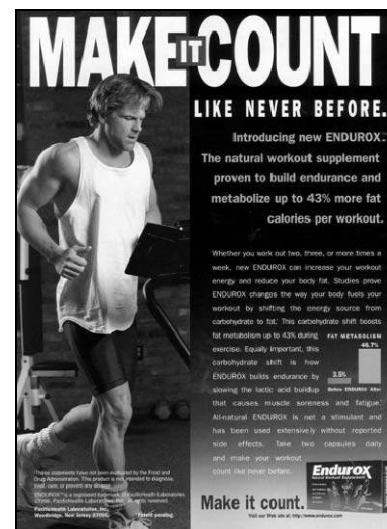


Figure 17. Nutritional quackery flags are described in the text.

Red flags for the Endurox product advertised in Figure 17 include:

- Sell word: "natural."
- Use of key words: "can" or "may," which mean anything is possible.
- Statements unsupported by science/FDA.
- Most "losing fat" claims are bogus.

Read More

For a more detailed analysis of not only the advertising copy, but also the "science" underlying a popular sports nutritional, see: *A Look at Endurox R4* on page 154.

Product Promotion

Lies of Omission

Studies are usually funded by companies looking to promote their product. Unfortunately, excellent or better alternatives are often not investigated.

For example, glycerol is marketed to athletes to improve hydration. Simple salt may be as helpful as glycerol—but there is little profit margin for small companies in selling table salt.

Fact Suppression

Companies put their best face forward. They passively, and sometimes actively and illegally, suppress unfavorable information.

If you think that cannot happen, consider two recent reports about the pharmaceutical industry, reproduced below. The regulation and scrutiny of drug manufacturers is much higher than that of sports nutritionals.

1. From *The New York Times*, October 1, 2004.

For Merck, Defense of a Drug Crumbles at a Difficult Time **By BARRY MEIER**

For years, evidence mounted that the pain reliever Vioxx might increase the risk of heart attacks or strokes. For years, its maker, Merck, disputed such findings.

A week ago Thursday, Merck's defense started crumbling, with the arrival of irrefutable evidence from one of the company's own studies that Vioxx doubled a long-term patient's chance of having such problems. And yesterday, after a frantic week of internal huddles and meetings with regulators, Merck announced that it would withdraw the drug from the worldwide market.

In many ways, the short but highly profitable history of Vioxx may prove to be a story about the triumph of marketing over science. Even though worrisome evidence began to emerge shortly after the drug's approval five years ago, sales of Vioxx soared to \$2.5 billion last year on the strength of one of the biggest direct-to-consumer marketing campaigns yet for a prescription medication. In

the first six months of this year alone, Merck spent an estimated \$45 million advertising the drug.

"It is a terrifying testimony to the power of marketing," said Dr. Jerry Avorn, a divisional director at Brigham and Women's Hospital in Boston.

2. From *The San Diego Union*, October 5, 2004.

Genentech gets subpoena regarding drug marketing **By PENNI CRABTREE**

Genentech said late yesterday that it received a subpoena regarding the marketing of its cancer drug, Rituxan, which was developed by San Diego's former Idec Pharmaceuticals.

The subpoena, from the U.S. Attorney's Office for the Eastern District of Pennsylvania, requested documents related to the promotion of the prescription drug. A Genentech spokeswoman said the company is cooperating with the investigation, which is both criminal and civil.

Federal authorities have been looking into the marketing practices of a number of drug companies. Johnson & Johnson faces an investigation by the U.S. Attorney's Office in Boston into the sale and marketing of its epilepsy drug, Topamax, while J&J, Wyeth and Forest Laboratories face a federal probe into the marketing of their top anti-depressant drugs.

Most of the investigations center around drug company marketing tactics to persuade doctors to favor the drugs over competitors' drugs, or to prescribe a drug broadly for uses not outlined on the label.

The Food and Drug Administration generally approves a drug for certain specific uses, though doctors are free to prescribe it for other "off-label" uses. Active promotional efforts, however, are supposed to be limited to the approved uses.

Endorsements

Endorsements or anecdotal testimonials are often used. Athletes, authors, or coaches may sound authoritative and convincing. Remember, companies are essentially hiring actors when they obtain endorsements.

The ad copy sounds powerful: "There's a point in the race, when if I need to, I can shift into a gear that's not found on any bike."²³

What does that really mean?

²³ Chris Horner, professional cyclist, endorsing PowerBar drink products in a two-page spread in *VeloNews*, December 20, 2004.

The ad copy sounds too good to be true: “After switching to the PR*Bar and 40/30/30 Nutrition Program, I excelled from ‘sport’ to ‘elite’ class mountain bike racer. I was also able to lose those last 5 pounds of body fat and maintain my racing weight throughout the year.”²⁴ It is a giant leap, however, to conclude that the product will do the same for you.

Ploy: Additives

Products may be mixed with other substances to market them more effectively. Many manufactures add ingredients to give justification to the cost of their products, distinguish their product, create the illusion of quality, or to confound the buyer, who may think: “Maybe *this* part of the product is hope, but maybe *that* part of the product works.”

Energy bars, for example, apparently cannot stand on their own. The original intent of providing ready-to-eat calories will not sell enough bars unless consumers believe they should pay for the added value of vitamins and minerals. Consider:

- Power Bars
Vitamins and minerals added. But why?
- Cytomax
Contains alpha-L-poly lactate. Sounds good, maybe? What is this proprietary additive?
- Endurox R4
Has used the herb Ciwujia. Has any study shown that this herb is helpful? Might it not be harmful? Might it contain banned contaminants? For a detailed examination of Endurox R4 claims, see page 154.
- VO2 Max Bars
That orange nutrient center looks good to some. Does the food coloring improve performance?

²⁴ Jack Orness—Rancho Bernardo, California, in a print copy ad for PR* Bar. See Figure 16 on page 141.

Buzzwords

Low cholesterol becomes a buzzword, and foods that never had any cholesterol in the first place are now marketed as having none. *Diet, lite, natural*, and other misleading and meaningless words are added to advertising copy to sell product.

The FDA limits the use of some buzzwords. Read more about approved nutrient content in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Retailers

Retailers are generally completely uncritical of the marketing copy for the products of the manufacturers they carry. Retailers typically repeat, verbatim, the advertising copy of manufacturers.

Be Cautious with Health Food Stores

You can get vitamins, minerals, and “natural” foods from the health food store. You can also get herbs and other “natural remedies.”

There are many reasons to be cautious about this practice. Substances sold as remedies in health food stores are unregulated. “Natural” is not necessarily any better than synthetic—natural mushrooms or hemlock can kill you too!

Studies show that:

- It is uncertain what the active ingredients are.
- It is uncertain whether substances are in a form that will be available for your body to use.
- It is uncertain what else is mixed in with the pills.
- It is uncertain whether the pills are safe.
- It is uncertain whether the product is formulated consistently from batch to batch.

- It is uncertain whether the same ingredients are present in the next bottle.

A report in *Consumer's Reports* on a certain brand of ginseng showed that amounts of ginseng per dose varied by a factor of 10, even though the bottles were labeled as having the same quantity. Whether there is any good reason to believe ginseng works is another matter entirely.

Supplements have always been hot in America. They are held to a lower standard than drugs. As Brad Stone, an FDA spokesperson, notes, "A company must show a drug is safe and effective before it gets approved. With supplements, the burden of proof is after the fact. The FDA must show that a product is unsafe to take it off the market."

Over the years, we have often heard excuses from tested athletes caught by drug control that they did not realize that the banned substance was in their favorite supplement. Professional athletes cannot afford to take such chances.

For a fuller discussion about problems with dietary supplements, see page 150.

Magazine Reports

Journals and lay magazines publish what is new and what may work, not what doesn't.

If a new product comes to their attention, what counts is whether reporting is newsworthy—whether it advances knowledge or whether it will sell more copies or advertising.

Some magazines give an uncritical and positive slant to every new item: they do not want to offend any potential advertisers and want to keep positive about the industry. Whether or not, and how well the product works, is less important. For these publications,

negative reports do not sell. Their readers are not interested in what *not* to buy; they are interested in what new product they might *try*.

Private companies usually fund research. Good sport science lags marketing and advertising. Said differently, marketing and advertising hype predates good science

Journals and magazines publish articles that something does not work only after the common belief is that it does work—then it is again newsworthy or sells copy.

Magazines are sometimes motivated to report negative results under the headline of reporting *new* research, often from competing private companies funding essentially negative reports about another product and promoting their product as better.

It is often not reported that the old product was *bad*, just that the current one is *new* and *improved*.

Coaches

Some coaches may provide an honest opinion, based on experience and knowledge.

Unfortunately, many other coaches have conflicts of interest, receiving sponsorship product or kickbacks from manufacturers, and often fail to disclose their conflicts.

Political Manipulation

Charges that politicians make studies fit their agendas are well known. Such accusations increased during the Bush administration.

Barton Reppert, writing in the *Christian Science Monitor* noted:²⁵

"In theory, science is supposed to be cold, analytical, dispassionate - and studiously apolitical. But in the real world of competing demands for federal research dollars, savvy scientists of

²⁵ <http://www.csmonitor.com/2004/0106/p11s02-coop.html>. Accessed 10-23-2004.

all disciplines - from cognitive psychologists running rats through mazes to nuclear physicists operating massive particle accelerators - recognize that a certain amount of political meddling in their research by policymakers in the executive branch and Congress is to be expected.

However, there are limits—limits the Bush administration has frequently disregarded by imposing stringent political controls on a broad variety of federal scientific programs and activities. This has raised acute concern in the American scientific community that the administration's drive to stamp its conservative values on science isn't just affecting policy decisions, but undermining the integrity of the US research infrastructure itself.

Some examples of the Bush administration's interference with science include:

- The removal from a National Cancer Institute website of a scientific analysis concluding that abortions do not increase a woman's risk of breast cancer.
- Dropping a leading addiction expert from the University of New Mexico, Dr. William Miller, from consideration for membership on the National Advisory Council on Drug Abuse after an administration aide quizzed him about whether he opposed abortion ("no") and had voted for Bush ("no").
- The elimination of the section on global warming in a comprehensive Environmental Protection Agency report on the environment last June. EPA officials decided to eliminate the section on climate change after an earlier draft prompted the White House to demand major revisions."

Outright Quackery

It is charitable to think that a researcher or journalist is after the absolute truth. Sometimes the truth is ugly. The profit motive is large in the motivations of any industry. Marketing costs may be huge.

Somebody must pay for those full-page ads. Selling the product is how people make their living. While most do not deceive intentionally, some do.

Ergogenics, Drugs Revised

Consider these products promoted in the past as new and wonderful, now known to be not so wonderful:

Over-the-Counter

- Androstenedione: Yes Mark McGuire may have set home run records and many men may have rushed to purchase this then over-the-counter anabolic steroid. Reports of breast development and other harmful side effects have led to this supplement's withdrawal.
- Antioxidants: How could increasing one's intake of antioxidants be harmful? Every one was convinced by marketing that exercise-induced free radicals led to cancer and that high doses of antioxidants would decrease the risk of cancer, improve performance, and be a panacea. Unfortunately, in the real world, studies reported increased deaths in groups taking beta-carotene, and supplement manufacturers toned down their hype of this anti-oxidant. The enthusiasm for other antioxidants will continue unabated—until the next negative report.
- Calban.²⁶ Usage of guar gum, an over-the-counter weight control product, greatly increased in 1985 when Calban, a new brand, was heavily promoted. Guar gum products are intended to expand in the stomach when hydrated. It was later found that if insufficient water was ingested with the product, the guar gum could swell in the esophagus, rapidly forming a heavy, viscous, adhesive mass.

A well-documented report of a death attributed to surgical

²⁶ <http://www.fda.gov/medwatch/report/desk/casestud.htm>. Accessed 10-4-2004.

treatment of guar gum-associated esophageal obstruction led to a recall of weight-control products containing this ingredient. Investigation identified 17 cases. Evaluation of this series of cases resulted in a product recall and a reclassification of weight control products containing guar gum as, “not being generally recognized as safe and effective.”

- Chromium: The strength gainer, weight control, and cholesterol reducer of the nineties found its way into, and remains in many supplements marketed for enhancing strength. Unfortunately, some sources were found to be toxic and carcinogenic.
- Creatine: Every athlete needed this product, until many found no improvement in aerobic endurance performance, and others noticed fluid retention or that cramps worsened their performance.
- Laetrile: This over-the-counter apricot pit cancer-cure-all turned out to be not so much a cure-all as a toxic make-all-sick.
- L-tryptophan: Marketed to help sleep. However, unregulated for purity, sources turned out to be contaminated and associated with over 1,000 cases of the muscle disorder eosinophilia-myalgia syndrome. Withdrawn from the US market 1990.
- Metabolife: One of the all-time hyped weight-loss methods, the company is now being sued in a class action lawsuit and the CEO indicted for misleading the public about the serious side effects of one of its components, ephedrine. We all know ephedrine is bad *now*; but then many thought it great.
- Melatonin: Has been touted as a cure-all for everything from sleep disorders and jet lag to cancer and AIDS. By some accounts, it can prevent or cure diabetes, cataracts, Alzheimer’s disease, schizophrenia, and epilepsy. Its proponents have claimed that it can reverse the aging process and energize a lackluster libido.

A recent editorial in *Nature* quotes Dr. Fred Turek, Director

of the Center for Circadian Biology and Medicine at Northwestern University, Chicago: “The data are simply inconclusive.” Says Dr. Richard Wurtman, director of clinical research at MIT: “Melatonin has been vastly overhyped.”

For more about problems with melatonin, see page 151.

Prescription

It is not just unregulated over-the-counter substances that are potentially toxic. Pharmaceutical drugs must be proven safe and effective in order to be marketed. The pressure on the FDA to approve new drugs is great, and many important side effects are known only after many decades of use, sometimes by tens of millions of people.

From the years 1979 through 2000, roughly 3% of all new drugs were later withdrawn because of problems, often life-threatening.²⁷

If heavily-regulated products regularly have such problems, it is easy to project that unregulated nutritionals, products that don’t have to be proven effective or safe to be marketed, may be more problematic.

Consider these recent drug problems:

- Estrogens: Thought to be a fountain-of-youth for menopausal women, and thought to improve memory and brain function. Only after use for many decades by more than 100 million women did studies indicate that, overall, estrogens worsen brain function and shortened life expectancy.
- Cholesterol-lowering drugs: Can lowering cholesterol be a bad idea? Well yes, if the agents used increase depression and suicides—as some are reported to do.
- Baycol (cerivastatin, cholesterol-lowering drug). Rhabdomyolysis (severe muscle reaction with cell death). Withdrawn 2001.

²⁷ <http://www.fda.gov/cder/present/roundtable/sld004.htm>. Accessed 10-16-2004.

- Lotronex (alosetron, gastrointestinal track motility problems, irritable bowel syndrome). Severe constipation and ischemic colitis. Withdrawn 2000.
- Propulsid (cisapride, gastrointestinal track motility problems, irritable bowel syndrome). More than 70 deaths due to heart-rhythm abnormalities. Withdrawn 2000.
- Raplon (rapacuronium, anesthetic). Fatal bronchospasm. Withdrawn 2001.
- Rezulin (troglitazone, diabetes). Liver failure. Withdrawn 2000.
- Seldane (terfenadine, allergies). Potential fatal heart rhythm abnormalities. Withdrawn 1998.
- Serzone (nefazodone, antidepressant). Liver failure. Withdrawn 2003.
- Vioxx (rofecoxib, analgesic, anti-inflammatory). Studies showed a doubling of the risk of heart attack. Withdrawn 2004.

Why Fall For New Gimmicks?

Why do we fall victim to nutritional quackery? After all, some new ideas will have merit, and it makes sense to be discerning and rationally try new products.

Whether it is snake oil, magic cures, or cults of one sort or another, “There’s a sucker born every minute.”

We do not want to be left behind, we want to do all that we can, and we are willing to take a chance. We are true believers that there is something out there that will work, help us, give us that edge.

Most of us, at some level, lack confidence. We are willing to try to get something for nothing, or not much.

If we are burned, scammed, or otherwise disappointed, many of us consider the product cost the price of admission.

Why do so many people give their hard-won earnings to the slot machines in Las Vegas? Maybe we will be lucky; maybe we will hit it big. If we do not try it, it cannot help us.

However, we can lose. We can lose more than our money. Nutritional supplements can harm health. Contaminants, as we have seen can be a problem. Over-the-counter does not mean innocuous or safe.

Take a chance?



The Bottom Line

You already have enough to concentrate on to help you stay fit—for example, proven training methods, a balanced diet, and plenty of recovery and rest.

In medicine, new drugs are called experimental for a reason. Side effects are common.

In the computer age, the first in line is called a beta-tester. Computers often crash.

In nutrition, the first in line for a new product is likely to be a guinea pig.

Concentrate on using tools that are known to work, not what might. *Caveat emptor.*

Supplement Hype²⁸

Many supplement manufacturers suggest that their products have characteristics that make them unique and/or better than those of their competitors. For example:

- Nat-rul Health Products has offered “all-day protection” with timed-release vitamin-mineral formulas.
- RichLife has offered OrganiMins, “the uniquely chelated Organomineral complex that’s nutritionally targeted for specific organs.”
- Sears Shop at Home Service’s Vitamin Improvement Program, has assured “purity, freshness, and quality” by shipping a fresh supply every ninety days.
- Albion Laboratories has claimed to have discovered “a way to target specific chelated minerals to specific areas of the body.”
- Makers of KAL, in a pitch to people with a busy, active lifestyle, has stated that its “high-potency” vitamins “dissolve in minutes instead of the hour or more that some lazy vitamins take.”
- MegaFood has said that it “employs nature’s unsurpassed Life Processes to actually grow Whole Food Vitamin and Mineral Concentrates” that are “up to 16 times more effective than ordinary ‘natural’ supplements.”
- JS&A has marketed a twice-a-day vitamin/mineral product, formulated by “a group of nutritionists, dietitians, dermatologists, biochemists, and physicians,” based on the notion that some vitamins are best taken in the morning and others at night.
- Ortho Molecular Nutrition International has stated that its vitamins and minerals are “biologically activated with nutrient carriers and absorption factors that make them superior to all other types.” (To support this claim, the company stated that, in a controlled test, baby rats given Ortho Molecular nutrients grew 2,206% faster than baby rats given conventional nutrients.)
- Profitable Nutrition Distributors, Inc. has stated that its sustained-release, high-potency formula includes “trace minerals which are naturally chelated and are in the exact proportions that exist in ancient sea water from which life arose.”
- Country Life has offered “cellular energy activators.”
- NutriLogic promises that its “ultimate blend of highly bioavailable minerals transport total nutrition to all parts of your cells.
- Rainbow Light Nutritional Systems has labeled its nutrients as “food-grown.”
- IntraCell Nutrition, Inc. has described the nutrients in its Foodform Manna as “protein bonded... vitamins and minerals in their original state.”
- American Health’s Total Energy Lift has been described as a “high-test formula” containing “over 100 ‘energy-lifting’ food source nutrients.”
- The makers of Sun Chlorella (a type of alga) have claimed that it is “not a substitute for vitamins or minerals, but is an ideal way to get more out of your vitamins and minerals.”
- Makers of KAL has claimed that its Multi-Active tablets “provide all the Designer Food Activity found in 4 pounds of fresh broccoli, apples, Brussels sprouts, potatoes and alfalfa sprouts combined.” (KAL defined Designer Food Actives as “the extraordinary health-giving compounds locked inside fruits and vegetables-that scientists have recently linked with important health benefits.”)

²⁸ Written by Stephen Barrett, M.D. From Quackwatch. <http://www.quackwatch.org/index.html> Accessed 10-11-2004. Reproduced by permission.

Most of these claims are pure hype. “High potency” is a misnomer because above-RDA doses are more likely to cause harm than they are to provide benefit. Nutrients are not “targeted” but are carried throughout the body in the bloodstream and are used as needed. Some nutrients are better absorbed when taken during mealtime, but the time of day is not important. Timed-release supplements are not advantageous because the body does not need a continuous supply of nutrients. Nutrient deficiencies do not develop by the hour or overnight. Biochemical reactions are driven by nutrients that are stored, as well as by those that are ingested during a given day. People eating a varied and balanced diet will maintain stores that can last for weeks or even years, depending on the nutrient involved. The body generally uses what it needs and excretes or stores the rest.

A few situations exist in which absorption characteristics are important. Calcium products vary significantly in their absorbability. And sustained-release niacin, which can be a potent drug for treating abnormal blood cholesterol levels, is less likely than ordinary (crystalline) niacin to cause flushing or burning of the skin but is far more likely to cause liver toxicity. Some of the above products may be absorbed more rapidly, more completely, or more steadily than others. But aside from dosage (megadoses are more likely to cause trouble), such characteristics are unlikely to make much difference.

Many manufacturers feature supplements that contain no sugar, preservatives, or artificial color or flavor. Others are touted to be “yeast-free.” These products are an attempt to capitalize on groundless fears—generated by the health-food industry itself.

Some companies state that their supplement products are patented. The U.S. Patent Office does not require proof that a product actually works; the main requirement is that it be different from previously registered products.

Many companies buy their ingredients from bulk manufacturers such as Hoffmann-La Roche and repackage them under their own brand name(s). As a result, many products claimed to be superior are actually identical to competing products.

*From The Medical Letter*²⁹

Supplement Problems

Millions of people take herbal products and other dietary supplements.

The Law

In 1994 the US Congress passed the Dietary Supplement Health and Education Act, which was intended to keep the FDA from regulating vitamins and herbal products as drugs.

The law permits the continued marketing of dietary supplements sold before October 15, 1994 (defined as vitamins, minerals, botanicals, amino acids and substances such as enzymes, organ tissues, glandulars and metabolites) without the review or approval of any government agency.

To market a new ingredient, a manufacturer must notify the FDA and demonstrate that it is reasonably expected to be safe.

Health claims can be made on the label—provided the claim also includes a disclaimer saying that the product is not intended to diagnose, treat, cure or prevent any disease.

All ingredients must be listed on the label.

The FDA can remove adulterated or mislabeled products from shelves, but the burden of proof (and discovery) is entirely on the government.

Manufacturers and distributors of dietary supplements are not required to record, investigate or forward to the FDA any reports they receive of injuries or illnesses that may be related to use of their products.

Quality

The Physicians' Desk Reference indicates which herbal drugs are recommended by the German Commission E, a quasi-governmental agency that publishes monographs on these drugs. The monographs generally do not include references. Potency and purity standards are available in the German Pharmacopoeia and Pharmacopoeia Europa.

Some drugs sold as dietary supplements in the US are sold as prescription drugs in Europe.

US pharmaceutical firms that have tried to manufacture pharmaceutical-grade dietary supplements that meet the same Good Manufacturing Practices (GMPs) used to prepare prescription drugs have found that the cost of doing so made their supplements too expensive to compete with much less expensive products already on the market.

GMPs for dietary supplements in the US are still under development.

Some Specific Concerns

Aristolochic Acid

In 1991 and 1992, about 100 women in Brussels who had taken Chinese herbs for weight loss developed rapid deterioration of renal function. Biopsies showed fibrosing interstitial nephritis. At least 70 of these patients have required dialysis or transplantation, and 18 have developed urothelial cancer.

The cause proved to be aristolochic acid, a known nephrotoxin from an herb probably included in the product by mistake.

Laboratory analyses by the FDA have detected aristolochic acid in botanical products and dietary supplements sold in the US.

²⁹From The Medical Letter. Vol 44. Issue 1140 September 30, 2002. Reproduced with special permission.

Kava

The FDA recently advised the public about the potential risk of severe liver injury, including cirrhosis and liver failure, associated with use of kava-containing dietary supplements.

At least 4 affected patients have required liver transplants.

According to the FDA, 21 different names are used for kava on the labels of dietary supplements.

Canada and some European countries have removed kava from the market.

PC Spes

A February 2002 letter from BotanicLab warned their customers that the California Department of Health Services had found that PC Spes, an herbal dietary supplement with estrogen-like effects sold for “prostate health,” appeared to be contaminated with the anticoagulant warfarin (Coumadin, and others).

A second letter in March told customers that alprazolam (Xanax, and others) had also been found in PC Spes.

A recent laboratory analysis of PC Spes manufactured between 1996 and mid-1999 found that the concentrations of listed ingredients thought to be active varied from lot to lot, and some lots also contained indomethacin (Indocin, and others) and the estrogen diethylstilbestrol.

Echinacea

Echinacea is a dietary supplement widely used for prevention and treatment of colds.

In vitro or in vivo pharmacologic activity has been reported for various constituents of these plants.

The amounts of these constituents vary in any particular formulation, depending not only on the species and plant part, but also on the season of harvesting.

In one study of 12 products marketed in the US, the percentage of phenolic compounds such as cichoric acid (which may or may not be an active ingredient) varied from brand to brand and within different lots of a single brand.

Echinacea products, like other herbal dietary supplements, may contain a wide range of organochlorine pesticides, including some that are banned in the US.

Melatonin

In a published study, mass spectrometry identified 7 contaminants in 3 different commercial preparations of melatonin, including some contaminants previously found in L-tryptophan associated with an epidemic of eosinophiliamyalgia syndrome that occurred in the US in 1989.

An evaluation of the physical qualities of 9 commercial melatonin tablet products found excessive friability, failure to disintegrate and excessive variation in hardness.

Glucosamine

Investigators in a National Institutes of Health study of glucosamine and chondroitin for treatment of arthritis could not find a satisfactory source that contained consistent amounts from batch to batch and had to manufacture the drugs themselves.

Conclusion

The main problems with dietary supplements, even if questions about their effectiveness and adverse effects were answered satisfactorily, are that their potency may vary and their purity is suspect.

Physicians should tell their patients that we really don't know what's in them.

Herbal Concerns

New Hope is a natural products industry trade and consumer publications company. It provides “integrated market solutions,” runs trade shows, and operates online trade and consumer websites.

At one of its annual conferences, a roundtable discussion of some of the industry’s problem products took place.

Here is a list of controversial products mentioned in the roundtable as reported by Rob McCaleb, President, Herb Research Foundation.³⁰

- Beta carotene—the recent report by NIH that it doesn’t help and may increase cancer risk (in smokers) is raising questions among consumers. The weight of evidence seems to support this antioxidant, and there are serious questions about the study, which combined beta carotene with vitamin A (retinol) at toxic levels, then gave it to smokers who are already at risk. Nature provides vitamin A (in fruits and vegetables) in the form of 90% beta carotene, and at lower doses than those used in the study.
- Chaparral—implicated as a liver toxin, but without strong evidence. Reported cases of human toxicity are complicated and rare, no liver toxic compounds have been identified, and the FDA, which has done some feeble testing with cultured liver cells but no classic toxicology testing, has been unable to come up with compelling evidence of harm.
- Chromium picolinate—widely sold in diet and muscle-building products. Does it work? It is an “insulin potentiator” which may improve some metabolic factors, but needs more research.
- Cleansing programs—many are based on stimulant laxatives, which can be habit-forming. The concept that we need to use laxatives to “clean out” is controversial.
- Comfrey—contains liver toxins called pyrrolizidine alkaloids. Some feel it is safe for most people, others see no point in taking any risk if other herbs can offer similar benefits. Roots have more alkaloid than leaves, and young leaves more than older leaves.
- Ephedra—after over 5,000 years of human use, the herb is controversial because of abuse in diet and energy products and the use of strong concentrates in products. Some products contain synthetic ephedrine, just like asthma drugs.
- Evening Primrose Oil / Black Currant Oil—are sources of the fatty acid gamma linoleic acid or GLA, beneficial to the cardiovascular system and reportedly effective for PMS and inflammatory conditions. FDA tried to claim that they were “unsafe food additives” but never had a shred of evidence of harm. The Agency lost (badly and repeatedly) in court.
- Germanium—rose to popularity, and then declined as cases of toxicity were reported. Germanium is only healthful in very low doses.
- Grape seed extract / Pine bark extract / “Pycnogenol”—are confusing to consumers. What are the differences? Is one better? Grape seed extract predominates in the European market, while pine bark extract is stronger in the USA, probably because of better marketing.
- Hemp—more products are appearing using the seed oil, which lacks the intoxicating components of the plant, also known as marijuana. No toxicity concerns, but the plant is controversial for obvious reasons.

³⁰ <http://www.herbs.org/greenpapers/controv.html>. Accessed 10-17-2004.

- Kava kava—becoming popular as a sleep aid and anti-anxiety agent. Concerns are about potential regulatory issues (no problems so far) and possible abuse.
- Kombucha “mushroom” products—evidence of benefits is weak. Concerns have been raised about safety of growing your own. The “brew” produced by this complex of microorganisms contains mostly vinegar, sugar, a bit of alcohol and caffeine.
- Laxative diet teas—can be habit-forming and produce unhealthful side-effects. Weight loss from such products may be mostly by dehydration, hence not lasting.
- Melatonin—synthetic hormone to induce sleep. Long term safety is uncertain, but it is produced naturally in our bodies.
- Organic Sugar—is this just a way to “sugar-coat” something that really isn’t healthful? Is the “green marketing” aspect exploitive?
- Selenium—same issue as germanium, complicated by the fact that areas with high selenium levels in the soil produce selenium-rich vegetables. In those areas supplementation is not necessary and could be hazardous.
- Single amino acids—including tryptophan, phenylalanine, aspartic acid and others, are controversial because they are isolated and taken in high doses. Safety may be a concern.
- Stevia—the embattled sweet herb, banned for 4 years based on a “trade complaint” (from a company, not a toxicologist), is now available as a dietary supplement. Looks safe.
- Stimulant diet teas—mostly ephedra, caffeine sources and sometimes willow or aspirin. They probably are appetite suppressants, and may stimulate fat burning. Some individuals should not touch them, for others there are questions about safety and healthfulness.

- Tryptophan—still off the market because of a quality problem with one manufacturer which led to illness and some reported fatalities. No one expects it to return to the market, but under the Dietary Supplement Health and Education Act of 1994 it would apparently be considered a safe and legal supplement unless FDA could prove otherwise.

Bottom Line

If the industry itself admits to these concerns, shouldn’t we as consumers be *at least* as concerned?

Product Promotion

A Look at Endurox R4

As an intellectual exercise, let us examine the nutritional claims and knowledge base that exists for the sports nutritional product Endurox R4. Then, let us consider a few alternatives to this product marketed to athletes.

The selection of Endurox R4 for this exercise is not meant as an endorsement or denigration of the product.

Endurox R4 is promoted as a recovery drink.

Endurox R4 is well-known, and typifies traditional nutritional marketing strategies (hype combined with limited science).

The Product



Figure 18. Endurox R4 canister.

Endurox is manufactured by PacificHealth Laboratories. The manufacturer's website is pacifichealthlabs.com.

Endurox is formulated with carbohydrate, protein, and electrolytes. It has contained the amino acids arginine and glutamine, branched chain amino acids, vitamins E and C, and ciwujia.³¹

³¹ According to the manufacturer, Endurox R4 was reformulated without Ciwujia in 01-2004 to meet NCAA and IOP rulings about ginseng.

The nutritional label information is reproduced in Table 28.

Serving size	2 scoops (75 g)
Total calories	270
Fat	1 gram 10 calories
Total carbohydrate	52 grams 208 calories
Sugars	40 grams 160 calories
Protein	13 grams 52 calories
Vitamin C	470 milligrams
Vitamin E	400 IU
Calcium	100 milligrams
Magnesium	240 milligrams
Sodium	210 milligrams
Potassium	120 milligrams
Glutamic Acid + L-glutamine	2.6 grams
Branched chain amino acids	2.7 grams
Arginine	1.7 grams

Table 28. Endurox R4 nutritional content.

Recovery Boosters?

The caloric source of most sports drinks, soda pop, and fruit juices is carbohydrate.

In addition to carbohydrate, Endurox has used the following “recovery boosters:”

- Adaptogens: Ciwujia
- Antioxidants: Vitamins E and C
- Branched-chain amino acids
- Arginine
- Glutamine
- Protein in a 4:1 “Optimal Recovery Ratio”

Is there any evidence that any of these substances is superior to plain sugar and water?

Let us examine each one in turn.

Adaptogens

Adaptogens are “food-grade herbal substances.” At first blush, herbs sound like a good idea to some consumers. As we have seen in the discussions on pages 143, 150, and 152, herbs can be problematic.

PacificHealth Laboratories previously used the adaptogen ciwujia, which sounds more exotic, perhaps, than its more common name: Siberian ginseng. PacificHealth Laboratories has claimed that ciwujia:

- Speeds recovery
- Adds stamina and endurance
- Decreases lactic acid buildup
- Promotes energy use from fat rather than from carbohydrate
- Boosts immune system

What evidence do the promoters of this substance offer? The published literature they quote is in Chinese. They offer no human research published in US or European scientific journals. The studies are not blinded nor controlled.

Some of the studies are in animals.

In one human study, the subjects are not athletes; they exercised only at moderate intensity. The longest exercise bout lasted 60 minutes.

After the Endurox R4 product was promoted, Cheuvront, Moffatt, et al; of Florida State University performed a double-blind crossover, placebo, random study of 10 subjects who consumed the recommended dosage of Ciwujia for 7 days. The subjects performed cycle ergometry. Their conclusion: The evidence did not support the advertised claims of reduced perceived exertion, reduced lactate production, and faster heart rate recovery.

Also after the Endurox R4 product was promoted, Dustman et al of Northern Illinois University performed a double-blind, random study of 10 subjects examining their physiological response to stair-stepping. Their conclusion: The evidence did not support advertised claims of increased fat metabolism, decreased lactate accumulation, faster heart rate recovery, or feelings of reduced fatigue during exercise.

PacificHealth Laboratories no longer formulates Endurox with ciwujia—it is banned by the NCAA.

Antioxidants

The claim: The addition of antioxidants (vitamins C and E, beta-carotene) reduces free radicals associated with exercise and therefore results in improved performance. Antioxidants may help prevent free-radical induced oxidative damage and prevent cancer.

Exercise does result in free-radical formation.

Although some changes in blood tests of immune function have been shown to follow antioxidant supplementation, it is a giant leap to conclude that this will improve function at cellular level, reduce cancer, or improve performance.

Studies to date are unconvincing of any role for antioxidant supplements in recovery products.

Antioxidants are not harmless. As discussed in the basic science section, beta-carotene antioxidants are associated with cancer and the addition of such supplements has been quietly withdrawn from many products.

For a fuller discussion about the antioxidants, read the basic science about vitamin A, beta-carotene, vitamin C, and vitamin E in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Branch-Chain Amino Acids, Arginine, Glutamine

The claim, popular in the late 1990s: Branch-chain amino acids improve performance by affecting serotonin, a brain hormone.

The evidence: Not convincing. Just the opposite. For example of six reported studies in 1998, no effect was noted. For example, Foster et al³² found no effect on serotonin, glucose, or lactate. There was no change in performance.

Arginine may stimulate the release of hormones including growth hormone and insulin. Glutamine may be a preferred fuel source for cells that line the gastrointestinal tract. Pharmacological dosing of these two amino acids is much higher than the amounts contained in an Endurox serving. The roles of these two amino acids as ergogenic agents are uncertain.

For a more complete review of proteins and amino acids, read the basic science section about protein beginning on page 56, the amino acid section on page 62, and the section on athletic considerations on page 63.

Remember: Amino acid supplements are not innocuous; they may be harmful.

Carbohydrate/Protein 4:1 Supplementation

The hype about protein for recovery began when Zawadski, in 1995, showed that added protein helps restore glycogen.

Subsequent research has shown that protein helps when carbohydrate intake is inadequate. When and if protein helps, additional carbohydrate helps even more.

The graph shown on the Endurox R4 manufacturer's website, Figure 19, from a study by van Loon,³³ demonstrating the value of

protein for glycogen resynthesis is politely and charitably best described as deceptive.

Why is Figure 19 deceptive? Because it implies that protein is important in recovery. In the van Loon study quoted, when one-quarter again as many protein calories were added to a carbohydrate recovery drink, glycogen synthesis almost doubled.

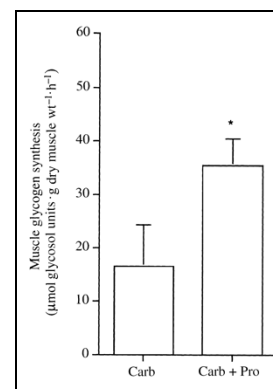


Figure 19. Glycogen synthesis is almost doubled when one-quarter again as many protein calories are added to a carbohydrate recovery drink. If you are impressed, look immediately below at Figure 20.

What the figure used by manufacturer did not show was what happened when just carbohydrate was used. Instead of adding one-quarter again as many protein calories, if one-quarter again as many carbohydrate calories were added, glycogen synthesis almost tripled.

When calories ingested were equivalent, carbohydrate was superior to a combination of carbohydrate and protein.

This is shown in the full figure, Figure 20.

³² Foster, C., Faria, E., Chinevere, T., & Faria, I. (1998). Effect of branched-chain amino acid ingestion on moderate and high intensity cycling. *Medicine and Science in Sports and Exercise*, 30(5), Supplement abstract 92. View online at <http://www-rohan.sdsu.edu/dept/coachsci/csa/vol53/foster.htm>. Accessed 11-15-2004.

³³ Van Loon, L.J.C., et al. (2000). Maximizing postexercise muscle glycogen synthesis: carbohydrate supplementation and the application of amino acid or protein hydrolysates mixtures. *The American Journal of Clinical Nutrition*. 72(106).

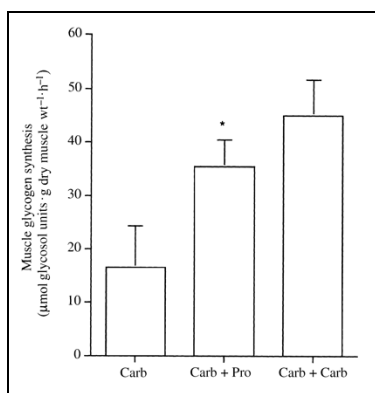


Figure 20. Glycogen synthesis is almost tripled when one-quarter again as many carbohydrate calories are added to a carbohydrate recovery drink. Figure 19 above is deceptive when used to promote the addition of protein rather than the ingestion of adequate carbohydrate calories.

The selective chopping off of the data to suit the manufacturer is deceptive.

There has been more research about protein and recovery, much of it negative.

Almost all of the research showing protein benefit has been conducted by Endurox R4's manufacturer, PacificHealth Laboratories or its paid consultants.

For a more complete discussion of the role—rather, the lack of a role—of protein in recovery, see the information beginning on page 66.

Endurox Hype

Here is the product description and other information taken from the manufacturer's website.³⁴

³⁴ <http://www.enduroxr4.com>. Accessed 1-28-2000.

Product Description

“The unique Endurox R4 formula (patent pending) includes electrolytes, high glycemic carbohydrates and whey protein in a 4:1 ratio (Optimal Recovery Ratio), arginine, antioxidant vitamins E and C, glutamine, branched chain amino acids and the natural herb, ciwujia. Endurox R4 is a total nutritional approach to muscle performance and recovery because it is specifically designed to:

1. Restore electrolytes and water.
2. Replenish glycogen stores rapidly.
3. Reduce muscle and oxidative stress.
4. Rebuild muscle protein.”

Hype Disguised as News Copy

Endurox R4 Beats Gatorade

Woodbridge, New Jersey (UW) - ENDUROX(R) R4(TM), a new sports drink developed by PacificHealth Laboratories Inc (Nasdaq: PHLI), has been shown to improve endurance performance by 55% over Gatorade, the leading sports drink sold in the United States.

This is the conclusion of a just-released study presented at the American College of Sports Medicine Mid-Atlantic meeting. It was conducted by Michael Williams and Drs. John Ivy and Peter Raven.

ENDUROX(R) R4(TM) Performance/Recovery Drink is the first sports nutrition product that will be introduced by PacificHealth Laboratories Inc. based on leading edge research that has redefined muscle performance and recovery.

According to Dr. Robert Portman, President of PHLI, “ENDUROX(R) R4(TM) represents the next generation of sports drinks” and is suitable for athletes “engaged in aerobic exercise...”

The investigators say ENDUROX(R) R4(TM) offers significant advantages over Gatorade because it enhances exercise performance, extends endurance, improves recovery and may protect against exercise induced muscle damage. Based on these studies, PHLI has filed a patent for ENDUROX(R) R4(TM).

Hype: Marketing Graphs and Ad Copy

Again, from the manufacturer's website:

"The results of the clinical trials provide powerful support that Endurox R4, by improving muscle performance and enhancing recovery, should be the product of choice for any athlete engaged in aerobic activities such as running, biking or swimming or team sports such as basketball, football or soccer."

To support this claim, the manufacturer compared Endurox R4 to Gatorade in two trials, and showed these graphic results:

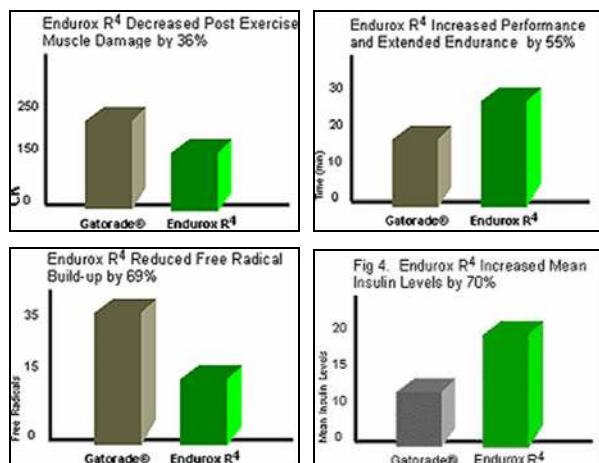


Figure 21. Manufacturer comparison of Endurox R4 and Gatorade. The text describes why these charts are misleading.

The Rest of the Story

Yes, in these manufacturer-sponsored trials Endurox R4 came out ahead of Gatorade. Yes, the studies were small, and abstracts, not published peer-review studies were quoted.

The real problem though is that the manufacturer was comparing apples to oranges. It is easily argued that Gatorade subjects were not

getting enough calories, not that the Endurox R4 product is superior because of its protein, antioxidants, or ciwujia.

In the first study, subjects received 560 calories of Endurox and 150 calories Gatorade.

In the second study, subjects received 335 calories Endurox and 134 calories of Gatorade.

What do you think the studies would have shown if subjects had received more calories from Gatorade and only a third as many calories from Endurox R4?

Endurox R4 Alternative Recovery Choices

I am not saying that there is anything wrong with Endurox R4 or similar products. They can be worthwhile if you like the taste and the convenience, and do not mind spending more than you otherwise might for equivalent nutrients.

	Endurox R4	Ultra Slim Fast
		
Serving	2 scoops in 12-oz	1 can, 11-oz
Total Cal	280	220
Carbohydrate Cal	210	165
Protein Cal	55	40
Fat Cal	15	15
Sodium, mg	230	240
Cost	\$2.15	\$ 1.19

Table 29. Endurox R4 vs. Ultra Slim Fast, selected nutritional content.

Endurox R4 chief selling point is its protein to carbohydrate ratio of 1:4, and a few other nutrients thrown in.

As discussed above, whether the protein or other nutrients have any value is debatable. Suppose you still think they may be helpful.

Consider how it compares to the more widely available Ultra Slim Fast:

Selected nutritional content of these two products is shown in Table 29.

Ultra Slim Fast has roughly the same 1:4 carbohydrate to protein ratio, and contains a more complete array of vitamin and minerals.

Some would argue that it more convenient, coming premixed as it does, and that it is tastier. It costs about half as much as Endurox R4.

	Fig Bars, Fat-free Milk	P&J, Fat-free Milk
		
Serving	2 fig bars, 12 ounces milk	½ peanut butter and jam sandwich, 8 ounces fat-free milk
Total Cal	285	295
Carbohydrate	190-210	156
Protein	65	64
Fat	0-20	72
Sodium	235	425
Cost	\$ 0.65	\$ 0.65

Table 30. Fig bars and milk; peanut-butter and jam sandwich and milk; selected nutritional content.

Or consider two other “real food” alternatives—readily available, tasty, and one-third the price: two fig bars with 12 ounces

of fat-free milk; or, with more fat calories, half a peanut-butter and jam sandwich with 8 ounces of fat-free milk.

Selected nutritional content of these products is shown in Table 30.

As you can see, for about one-third the cost, there are nutritious alternatives.

Finally, perhaps you think that the perfect recovery product has mostly carbs, and 10% to 15% protein and fat. A product that is tasty and not too expensive, one-third the price of Endurox R4?

Check out the listing for Häagen Dazs low-fat ice cream in Table 31.

	Ice Cream, Häagen Dazs
	
Serving	4 ounces
Total Cal	170
Carbohydrate	125
Protein	20
Fat	25
Sodium	95
Cost	\$ 0.75

Table 31. Häagen Dazs ice cream selected nutritional content.

Summary

Endurox R4 is promoted as a recovery drink. Its caloric profile would be expected to play an important part in recovery. It contains no proven ingredients beyond the calories it contains.

Part 6:

Body Fat, Weight

Part 6 is available in the free supplement. The supplement is published separately for ease of electronic transmission and manageable print volumes. To download the free supplement go to: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

Part 6 contains the following chapters:

- Measuring Body Fat
- Body Mass Index
- Obesity
- Tips to Lose Weight
- Disordered Eating
- Too Thin?
- Rapid Weight Changes
- Some Diet History

Part 7:

Healthy Fast Food

Part 7 is available in the free supplement. The supplement is published separately for ease of electronic transmission and manageable print volumes. To download the free supplement go to: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

Part 7 contains the following chapters:

- Breakfasts
 - French Toast
 - Muesli, Toast
 - Oatmeal, Egg McGuffin
- Dinners
 - Soup & Veggies
 - Chili & Veggies
 - Macaroni & Cheese Plus
 - Quick Salad
 - Big Fruit Smoothie
 - Cheerios, Milk & Banana
- Top 10 Veggies
- Top 10 Fruits
- Suggestions For The Culinary Challenged
- A Few Favorite Foods

Part 8:

USDA & FDA Basics

Part 8 is available in the free supplement. The supplement is published separately for ease of electronic transmission and manageable print volumes. To download the free supplement go to: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

Part 8 contains the following chapters:

- Dietary Reference Intakes
- “Nutrition Facts” Label
- “Daily Values” Label
- Supplement Values
- Nutrient Content Claims
- Health Claims

Part 9:

Vitamins, Minerals, and Other Nutrients³⁵

Part 9 is available in the free supplement. The supplement is published separately for ease of electronic transmission and manageable print volumes. To download the free supplement go to: <http://roadbikerider.com/nutritionforsportssupplement.htm>.

In this part, almost every vitamin, mineral, and other known nutrient important in human nutrition is discussed in detail. This part is relatively dry reading; the information is sometimes technical.

Due to its particular importance for athletes, the chapter on sodium is included below. This inclusion not only provides important information, it serves to illustrate the type of material found in the supplement.

³⁵ Major sources used for this part of the book are:

1. The Food and Nutritional Information Center (FNIC) at the National Agricultural Laboratory. The FNIC is part of the US Department of Agriculture (USDA) and the Agricultural Research Service. <http://www.nal.usda.gov/fnic/index.html>. Accessed 10-2004.
2. PDR (Physicians Desk Reference) Health. http://www.pdrhealth.com/drug_info. Accessed 10-2004.
3. Linus Pauling Institute. <http://lpi.oregonstate.edu/index.html>. Accessed 10-2004.

Sodium (Na), Chloride (Cl)

Description

Sodium and chloride (found in table salt) are essential minerals. A modest amount of salt is required for survival; the health implications of excess salt intake are controversial.

Sodium and chloride levels are tightly controlled in blood.

Most sodium and chloride in the diet comes from table salt.

Most nutritional focus is on sodium. What concerns chloride generally concerns sodium.

In the general population, the focus is on decreasing intake. In aerobic endurance athletes, the occasional focus is on increasing intake.

The total body sodium content of an adult is about 90 grams. About 30% is found in bone.

Requirements: Adequate Intake (AI)

The 2004 US Food and Nutrition Board (FNB) adult daily adequate intake levels for sodium chloride (salt), sodium, and hence chloride, are 3.8 grams, 1.5 grams, and 2.3 grams respectively.

These are based on the amounts needed to replace losses through sweat in moderately active people and to achieve a diet that provides sufficient amounts of other essential nutrients.

The USDA value for sodium, used for nutritional supplement and food labeling, is 2.4 grams.

The USDA value for chloride, used for nutritional supplement and food labeling, is 3.4 grams. A typical multivitamin/multimineral contains 72 milligrams (2%).

Typical Intake (Sodium Chloride)

The average US daily dietary intake is at least 9 grams for men and 6 grams for women.

Average dietary intakes of most people in the US are significantly higher than recommended.

Tolerable Upper Intake Level (UL)

The FNB adult daily tolerable upper intake level is 5.8 grams of salt (2.3 grams of sodium).

It is based on the adverse effects of high sodium intakes on blood pressure, a major risk factor for cardiovascular and kidney diseases.

The UL may be lower for those who are most sensitive to the blood pressure effects of sodium: African Americans, the elderly, and those with hypertension, diabetes, or chronic kidney disease.

Sources

Food

Most dietary sodium and chloride come from salt. By weight, about 40% of salt is sodium, 60% chloride.

Most salt intake in the US is from salt added during food processing or manufacturing, rather than from salt added at the table or during cooking.

Restaurant foods tend to be high in sodium.

The lowest salt intakes are associated with diets that emphasize unprocessed foods, especially fruits, vegetables, and legumes.

The sodium and energy (caloric) content of selected foods is listed in Table 32.

Product	Serving	Sodium	Carb	Fat	Protein	Calories
		mg	gm	gm	gm	
Salt, table	1 tsp.	2,200	0	0	0	0
Soy sauce	1 tbs.	1,300	0	0	0	0
Soup, instant	2 oz. dry	1,300	44	2	7	220
Chex Mix	1.75 oz	610	35	6	4	210
Pizza	3 oz slice	500	20	6	6	160
Pretzels	10	500	22	3	1	120
Pasta sauce	4 oz.	450	7	4	2	72
MetRx	8 oz	195	12	1	18	130
Spizerinctum	8 oz.	133	44	2	8	233
Fig bars, no fat	2	115	23	0	1	100
Gatorade	8 oz.	110	14	0	0	56
PowerBar	2.25 oz.	90	45	2	10	225
Exceed	8 oz.	50	17	0	0	70
Apple juice	8 oz.	15	29	0	0	116
Bananas	1 med.	0	30	0	1	125

Table 32. Sodium and energy (caloric) content of selected foods.

Many foods are available with high- and low-salt choices. In general, for good health, choose low-salt. To replace sodium lost in sweat, choose high-salt.

Product	Serving	Sodium milligrams	Salt milligrams
Tomato juice, salt added	1 cup	880	2,200
Tomato juice, no salt added	1 cup	20	60
Potato chips, salted	8 ounces (1 bag)	1,300	3,300
Potato chips, unsalted	8 ounces (1 bag)	20	50

Table 33. High vs. low salt. Similar products, dissimilar sodium content.

Salt

1 teaspoon contains 2,200 milligrams of sodium and 3,300 milligrams of chloride.

Supplements

The general population does not need supplements. Those with medical problems occasionally need to have electrolyte correction through intravenous solutions or to have their medications adjusted. Otherwise, if sodium or chloride levels are low, simply adding salt to food is simple and inexpensive.

Aerobic endurance athletes may occasionally profit from the use of sodium supplements, although, again, table salt is always the least expensive alternative, and when added to foods, stimulates thirst more appropriately than tablets or capsules.

Table 34 lists selected sodium supplements, as well as the number of servings (capsules or tablets) required to replace the 1,000 milligrams of sodium typically lost in one quart (liter) of sweat.

Several hours of exercise in the heat can result in more than 5 quarts (liters) of sweat; all-day exercise more than 10 quarts.

It takes roughly 250 Endurolytes capsules to replace the sodium lost in 10 quarts of sweat; it takes about 1½ tablespoons of salt.

Product	Manufacturer	Sodium Per Serving, milligrams	Servings Per Quart Sweat
Endurolytes	Hammer Nutrition	40 per capsule	25
Lava Salts	Lava Sports	110 per tablet	9
Succeed! Capsules	Succeed	341 per capsule	3
Thermolytes	SportQuest	150 per capsule	7
Thermotabs	Numark	180 per tablet	6
Table salt		2,200 per teaspoon	½

Table 34. Selected sodium supplements marketed to athletes.

Bioavailability

Absorption is greater than 90%.

Interactions

Interactions are listed in the footnote.³⁶

Function

Sodium (Na^+) and chloride (Cl^-) are the principal electrolytes in the fluid outside of cells (extracellular fluid), which includes blood plasma.

Sodium and chloride serve to maintain fluid levels, muscle function, and support the blood and lymphatic systems.

Membrane Potential

Sodium and chloride contribute to the charge differences across cell membranes.

Potassium concentrations are about 30 times higher inside than outside cells; sodium concentrations are more than 10 times higher outside than inside cells.

³⁶ Interactions

Nutrient

Diets emphasizing fruits, vegetables, whole grains, poultry, fish, nuts, and low-fat dairy products lower blood pressure compared to typical US diets. Potassium and calcium intakes are higher with such diets. The combination of such diets and reduced salt intake lowers blood pressure more than either intervention alone.

Drug

The following drug families and drugs increase the risk of hyponatremia (low blood sodium concentration):

Carbamazepine.

Chlorpropamide.

Clofibrate.

Cyclophosphamide.

Desmopressin. (Continued)

Diuretics, including hydrochlorothiazide, furosemide (Lasix).

Non-steroidal anti-inflammatory drugs (NSAIDs), including ibuprofen (Advil, Motrin), naproxen (Aleve).

Opiates, including codeine and morphine.

Oxytocin (Pitocin).

Phenothiazines, including prochlorperazine (Compazine) and promethazine (Phenergan).

Serotonin-reuptake inhibitors (SSRIs), including fluoxetine (Prozac) and paroxetine (Paxil).

Tricyclic antidepressants, including amitriptyline (Elavil), and imipramine (Doormil).

Vincristine (Oncoming).

These concentration differences across cell membranes create an electrochemical gradient known as the membrane potential.

Membrane potential is maintained by ion pumps in the cell membrane, especially the sodium- and potassium-ATPase pumps. Pump activity is estimated to account for 20% to 40% of the resting energy expenditure in a typical adult.

Cell membrane potential is critical for nerve impulse transmission, muscle contraction, and heart function.

Blood Volume and Blood Pressure

Sodium is the primary determinant of extracellular fluid volume, including blood volume.

Mechanisms that regulate blood volume and blood pressure work, in part, by adjusting the body's sodium content.

In general, sodium retention results in water retention and sodium loss results in water loss.

Digestion

Chloride, in the form of hydrochloric acid (HCl), is an important component of gastric juice, which aids the digestion and absorption of nutrients.

Nutrient Absorption and Transport

Sodium absorption in the small intestine plays a role in the absorption of chloride, amino acids, glucose, and water.

Similar mechanisms reabsorb these nutrients after they are filtered from the blood by the kidneys.

Deficiency (Hyponatremia)

Hyponatremia, a low blood sodium concentration, results from increased sodium loss or increased fluid retention.

Conditions that increase the loss of sodium and chloride include large sweat losses, severe or prolonged vomiting or diarrhea, the use of some diuretics, and some forms of kidney disease.

Increased fluid retention may be due to inappropriate anti-diuretic hormone (ADH, a pituitary hormone) secretion. Inappropriate ADH is associated with many drugs and diseases, including disorders affecting the central nervous system.

In some cases, voluntary excessive water intake may also lead to dilutional hyponatremia.

Symptoms of hyponatremia include headache, nausea, vomiting, muscle cramps, fatigue, disorientation, and fainting.

Complications of severe and rapidly developing hyponatremia may include cerebral edema (swelling of the brain), seizures, coma, and brain damage. Acute or severe hyponatremia may be fatal without prompt and appropriate medical treatment.

Exercise and Hyponatremia

Read about this under *Athlete Considerations* on page 166.

Disease Prevention (Salt Reduction)

Gastric Cancer

Studies in Asian countries indicate that high intakes of salted, smoked, and pickled foods increase the risk of stomach cancer.

Although high in salt, these foods may also contain carcinogens such as nitrosamines.

Populations with high intakes of salted foods tend to have low intakes of fruits and vegetables, which are also associated with increased risk of gastric cancer.

The risk of developing stomach cancer is increased by chronic inflammation of the stomach and infection by the bacteria, *Helicobacter pylori*. High concentrations of salt may damage the cells lining the stomach, increasing the risk of *H. pylori* infection.

Kidney Stones

Most kidney stones contain calcium. Elevated urinary calcium increases the risk of developing calcium stones.

Increased dietary salt increases urinary calcium excretion, and may contribute to calcium-containing kidney stones.

Salt restriction reduces urinary calcium in those with a tendency to form calcium stones; a diet low in salt and animal protein decreases stone recurrence more effectively than a low-calcium diet.

Osteoporosis

Increased salt intake increases the urinary excretion of calcium.

Each 2.3-gram increment of sodium (5.8 grams of salt) excreted by the kidney draws about 30 milligrams of calcium into the urine.

Studies are needed to determine whether decreasing salt intake improves bone mineral density or reduces fracture risk.

Read more about osteoporosis under calcium in the free supplement to this book available at:

<http://roadbikerider.com/nutritionforsportssupplement.htm>.

Disease Treatment (Salt Reduction)

Hypertension (High Blood Pressure)

Reduction of dietary salt has been advocated as a means to prevent and treat hypertension for more than 30 years.

The benefits of dietary salt reduction are controversial.

The most recent meta-analysis of data pooled from more than 100 studies found reducing salt intake by about 6 grams per day lowered blood pressure by 3.9/1.9 millimeters mercury (mm Hg, systolic BP/diastolic BP) in those with high blood pressure. Even greater reductions in salt intake lowered blood pressure by only 1.2/0.3 mm Hg in those with normal blood pressure.

Clinicians have questioned the value of such modest blood pressure reductions in hypertensive patients, although some studies show that these amounts could be important.

Salt Sensitivity

Some people may be more sensitive to the effects of salt on blood pressure.

Dietary salt restriction has been reported to lower blood pressure significantly in about half of those with hypertension and a third of those with normal blood pressure.

Salt sensitivity may be more common in obese and insulin-resistant individuals, and in African American, elderly, and female hypertensive patients.

Organ Damage

High salt intake may contribute to organ damage in ways that are independent of its effects on blood pressure. Increased salt intake may be associated with pathological changes in the structure and function of large elastic arteries that are independent of changes in blood pressure.

Toxicity (Hypernatremia)

Abnormally high blood sodium concentrations (hypernatremia) generally develop from excess water loss accompanied by an impaired thirst mechanism or lack of access to water.

Signs and symptoms of hypernatremia in the presence of fluid loss include dizziness, fainting, low blood pressure, and diminished urine production.

Hypernatremia may be caused by excessive sodium intake (for example, the ingestion of large amounts of seawater or intravenous infusion of concentrated saline solution).

Salt tablets do not stimulate thirst as much as salty foods do. Overzealous use of salt tablets has been associated with hypernatremia, especially when fluid intakes have been relatively low.

Ingestion of large amounts of salt may lead to nausea, vomiting, diarrhea, and abdominal cramps. Severe hypernatremia may result in

edema (swelling), hypertension, rapid heart rate, difficulty breathing, convulsions, coma, and death.

Athlete Considerations: Hyponatremia

Sodium is the electrolyte priority for the aerobic endurance athlete.

Loss in sweat: 230 to 1,700 milligrams per liter.³⁷

With an intake of 4,000 milligrams and an absorption efficiency over 90%, about 3,600 milligrams of sodium are absorbed daily.

With a loss of about 1,000 milligrams per liter of sweat, it is easy to sweat out about 4,000 milligrams of sodium with a gallon (4 quarts, 4 liters) of sweat. This could overwhelm your daily intake.

Blood sodium levels may drop. A low concentration of sodium in the blood is associated with weakness, fatigue, seizures, and occasionally death.

In temperate weather conditions, this may take 4 or 5 hours. In high-heat conditions, sodium depletion can occur in just a couple of hours.

In many athletes, low sodium problems first occur in target long-distance events—because these events may last 50% longer than the longest previous training session.

Many athletes, observing general healthy-diet guidelines, watch their sodium intake and keep it low. This is not necessarily a good strategy for most endurance athletes.

Hyponatremia is well-recognized as a problem in athletes competing in aerobic endurance exercise events such as marathons, century bicycle rides, and Ironman-length triathlons. Longer ultra-events place athletes at even higher risk.

³⁷ Biolab Medical Unit (UK) reference ranges. <http://www.biolab.co.uk/repse.html>. Accessed 10-28-2004.

In many events, beginners who spend longer than average on the course, especially those who overdrink salt-poor fluids, are most at risk. Many sports drinks are relatively low in sodium.

Cyclists may have a relatively easy time ingesting sodium snacks. Triathletes can ingest salt snacks while cycling. Runners tend to have finished their event before trouble with sodium sets in. Walkers, in the heat for many hours, are the most at risk, especially if they rely only on gels and water for their event nutrition.

For example, marathon walkers, who take 8 hours to walk a marathon, are more at risk than seasoned marathon runners who may complete the course in 3 hours.

In some large events, (1) when randomly tested, more than 20% of athletes have had hyponatremia and (2) more than 3% of athletes have required medical attention for hyponatremia.

In a study of Iditasport human-powered ultra-marathon athletes 7 of 16 (44%) had hyponatremia. These competitors drank more and consumed less sodium per hour than their normonatremic counterparts.

Another study showed that 89% of marathon runners had lower blood sodium levels after their marathon than before. Those most prone to hyponatremia lost less weight and drank more.

It has been speculated that the use of non-steroidal anti-inflammatory drugs (NSAIDs) may increase the risk of exercise-related hyponatremia by impairing water excretion; firm evidence is lacking.

For aerobic-endurance athletes, it is reasonable to plan on an intake of up to a maximum of one gram (1,000 milligrams) of sodium per liter of fluid loss. This is about one-half teaspoon of salt.

It is preferable to eat salty foods or drinks rather than ingest salt tablets. Studies have shown that salty foods and drinks appropriately stimulate thirst, and so prevent the unintentional ingestion of dangerously high amounts of sodium.

Many athletes who are sodium-depleted are also dehydrated. However, those with low blood sodium are often relatively less dehydrated than their competitors who have blood levels closer to normal.

The reason is that athletes tend to rehydrate with fluids that have a lower sodium concentration than blood. Those who drink the most tend to dilute sodium the most and have lower blood concentrations.

Here is another reason for consuming salt: It helps the body rehydrate.

Read more about sodium and sweat losses during events on page 21.

Bottom Line

Diets relatively low in salt (6 grams salt per day or less, 2,500 milligrams sodium) and high in potassium (at least 4.5 grams per day) are associated with decreased risk of high blood pressure and associated risks of cardiovascular and kidney diseases, especially in salt-sensitive individuals.

Fruits and vegetables (at least 5 servings per day) together with a low-salt diet may interact to further reduce high blood pressure risk.

Aerobic endurance athletes need to increase their salt intakes with workouts or events where more than several quarts (liters) of sweat occur.

Key Points

Here are the key points made throughout this book.

General Nutrition Key Points

- Eat a variety of whole, unprocessed foods in moderation.
- Eat at least half a dozen servings of fruits and vegetables daily.
- Control your weight.
- Limit or avoid alcohol.
- Eat a diet relatively high in fiber.
- Eat fewer simple sugars—candy, table sugar, “sweets.”
- Avoid junk food.
- Avoid high-fat and high-cholesterol foods.
- Avoid salty foods (unless you will be sweating quarts).
- Rely on food, not pills.
- Consider a multivitamin/multimineral supplement.

There are no absolute rules. Very different diets consumed by different people may have equal nutritional value and result in good nutrition. Occasional dietary indiscretions are not important.

Workout Key Points

Pre Exercise

- Start exercise well-hydrated.
- Start exercise glycogen-loaded in both muscles and liver.
- Supper: Pre-event meal high in carbohydrate. If planning to exercise for more than 4 hours, or 2 hours in high heat and humidity, add salt to foods.
- Breakfast: Cyclists aim for at least 1,000 calories. Runners may not be able to eat as much—perhaps only a few hundred calories. Walkers and triathletes will be in between.

- Pre-workout calories benefit both endurance and strength athletes, both aerobic and anaerobic work.
- Start prolonged exercise in the heat salt-loaded.
- Be prepared for start delays.
- At the event: Have easily digestible fluids and calories available in case of a start delay.

During Exercise

- Hydrate
 - Aim for at least 8 ounces (250 milliliters) of fluids, every 15 to 30 minutes, depending upon the heat.
 - Have carbohydrate-in-water solutions (for example, maltodextrins or sports drinks), rather than plain water.
 - Cyclists: Carry two waterbottles. Or use a hydration system (for example, CamelBak).
 - Walkers: Carry a waterbottle.
- Calories
 - For events longer than one hour, consume at least 300 calories per hour of exercise.
- Salt
 - For multi-hour events in conditions of heat and humidity, consume salty foods, and sodium-rich solutions and gels.

Post Exercise

- Refueling after exercise is a proven recovery strategy.
- The sooner the better. Refueling during exercise is best.
- Prompt refueling benefits both endurance and strength athletes.
- Prompt refueling benefits aerobic and anaerobic work.
- Aim to ingest at least 50 grams of carbohydrate (200 calories) within the first 30 minutes after

exercise and again every hour for the next 3 hours, up to caloric deficit.

- Some fat and some protein with the carbohydrate is no problem.
- “Real food” is probably better than specialty sports products.

Hydration Key Points

- Adequate hydration is crucial to athletic performance.
- Keep fluids handy.
- Begin training or events hydrated.
- The longer the event, the more important it is to keep up with fluid losses.
- For single-day events:
 - Aim to drink 16 ounces (2 cups, 500 milliliters, 1 standard waterbottle) per hour while exercising moderately or in temperate conditions.
 - Aim to drink up to 32 ounces (1 quart, 1 liter) per hour when exercising at high intensity or in the heat.
- For multiple-day events:
 - Replace fluids lost, up to 48 ounces (1.5 quarts, 1.5 liters) per hour when exercising in the heat.
 - Reduce exercise intensity to a level that allows you to replace what you are losing.
- Chilled and flavored fluids improve palatability and promote hydration.
- Carbohydrate concentration to a maximum of 6% (240 calories per quart or liter) may improve the rate of rehydration as well as improve performance by providing energy and sparing glycogen.

- Sodium to a maximum concentration of 1,000 milligrams per quart (liter) may improve the rate of rehydration as well as prevent hyponatremia.
- There is no evidence that other minerals in hydration products improve performance.
- There is no evidence that proprietary substances in sports drinks confer any advantages over readily available nutrients.

Macronutrient Mix & Carbohydrate Key Points

- Healthy diets are 60% carbohydrate, 25% to 30% fat, and 10% to 15% protein.
- Carbohydrate is the preferred fuel source for high-intensity exercise.
- Aerobic endurance athletes who exercise more than 10 hours per week benefit from a diet slightly higher in carbohydrate—typically up to 65% carbohydrate, 20% fat, and 15% protein.
- Even higher percentage carbohydrate diets may sometimes be best for aerobic endurance athletes.
- Aerobic endurance athletes may need 7 to 10 grams of carbohydrate per kilogram (3 to 4.5 grams per pound) of body weight per day to replace or top up glycogen stores.

Fat Key Points

- Keep total fat intake less than 30% of daily calories.
 There are 9 calories in a gram of fat.
 The maximum fat allowance in a 2,100-calorie diet is 70 grams a day.

- Dietary fat should be mostly mono- and polyunsaturated fatty acids
- Polyunsaturated fatty acids provide essential fatty acids (linoleic and alpha-linolenic acid).
- Keep saturated and *trans* fat less than 10% of daily calories.
- Keep cholesterol intake less than 300 milligrams daily.
- High blood levels of LDL and total cholesterol are dangerous.
- High levels of HDL cholesterol are desirable.
- Exercise regularly to raise HDL levels.

Protein Key Points

- Aim to ingest 10% to 20% of calories from protein. The upper end of the range is for aerobic endurance athletes exercising more than 10 hours per week.
- Said differently, aim for up to 1.5 grams of protein per kilogram (0.7 grams per pound).
- Watch for bad company—substances harmful for health that may accompany otherwise good protein sources.
- Get a mix of proteins. A variety of foods will ensure that you get all of the amino acids you need.
- Balance carbohydrate and protein. Keep up the carbs. Endurance athletes need carbohydrate for intensity training.
- Too much protein can potentially weaken bones.
- There is little evidence that athletes need protein supplements.

- There is little evidence that amino supplements are of value, except in a few disease states.
- Whey protein has no magical qualities.
- The role of protein in recovery drinks, if any, is overstated.

Vitamins Key Points

- Consider taking a multivitamin supplement.
- Do not waste money on fancy proprietary supplements.
- Do not supplement more than the RDA.
 Too much vitamin A is associated with osteoporosis, an increased risk of lung cancer, and hypervitaminosis A toxicity.
 Too much vitamin D is associated with hypercalcemia, osteoporosis, and hypervitaminosis D toxicity.

Minerals Key Points

- Consider taking a multivitamin/multimineral supplement.
- If you do not drink at least a pint of milk daily, consider taking a calcium supplement.
- If your diet is low in iron, or you have heavy periods, consider taking iron as part of a multivitamin/multimineral supplement.
- Do not waste money on expensive proprietary supplements.
- Do not supplement more than the RDA.

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To Search for Words

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From the menu bar choose EDIT > SEARCH, or
On the keyboard, press CONTROL F.
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