

Introduction to Sports Nutrition: Fuel for Fitness Week 3



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Outline

➤ Carbohydrate

- Functions & Fuel
- Diet Guidelines
- Loading
- As an Ergogenic Aid

➤ Lipids

- Functions and Fuel
- As an Ergogenic Aids



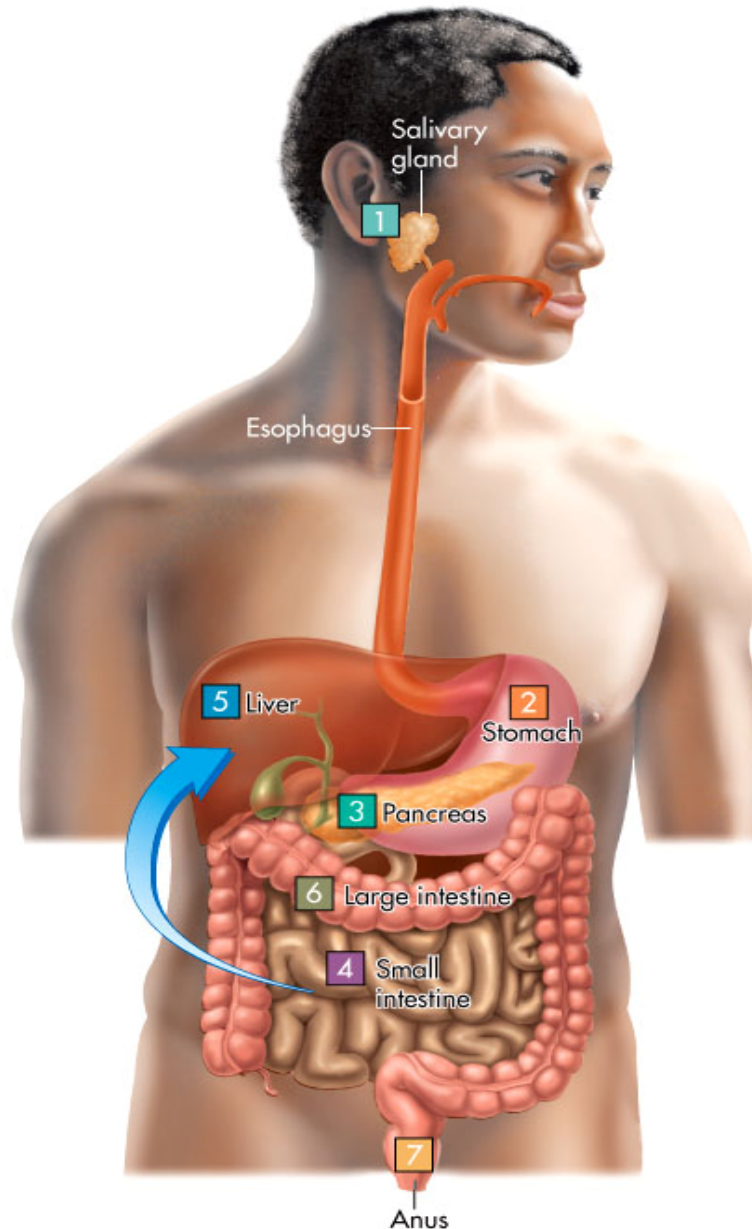


Chapter 4

Carbohydrates the Main Energy Source

Carbo-hydrate Digestion

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Carbohydrates



- 1 Some starch is broken down to maltose by salivary amylase.
- 2 Salivary amylase is inactivated by strong acid in the stomach.
- 3 Enzymes (amylase) from pancreas break down starch into maltose in the small intestine.
- 4 Enzymes in wall of the small intestine break down the disaccharides sucrose, lactose, and maltose into monosaccharides glucose, fructose, and galactose.
- 5 Absorption of glucose, fructose, and galactose into blood to be taken to the liver by a portal vein.
- 6 Some soluble (also called viscous) fiber is fermented into various acids and gases by bacteria in the large intestine.
- 7 Insoluble (also called poorly fermented) fiber escapes digestion and is excreted in feces, but little other dietary carbohydrate is present.

Carbohydrates -CHO

- Organic compounds that contain carbon, hydrogen, and water
- Simple
 - Monosaccharides
 - Glucose, fructose, galactose
 - Disaccharides
 - Sucrose = glucose + fructose
 - Lactose = glucose + galactose
 - Maltose = glucose + glucose
- Complex
 - Starches



Carbohydrates – CHO *

- The primary source of energy for your brain and body!
- CHO: Breads, grains, beans, milk, fruit, yogurt, vegetables, corn, potato, lentils



Nutrition, Carbohydrates & Diabetes

Carbohydrates: Include all “sugars” – dextrose, glucose, lactose, maltose, and fructose.



Healthy carbohydrates come with fiber, vitamins, minerals and phytonutrients. These foods are whole grains, low fat milk and yogurt, fruits & vegetables which help prevent disease.

- Fiber helps to lower blood sugar and cholesterol plus it helps to control weight by making you feel full.
- Carbohydrates are Not bad. They provide energy!
- Americans often choose the wrong kind of carbohydrates with too much consumption of snack foods which usually contain unhealthy fats and refined white flour.



Carbohydrates *

- Recommended Daily Allowance (RDA) for CHO is 130 grams/day
- Athletes should consume 55-60% of total calories as CHOs

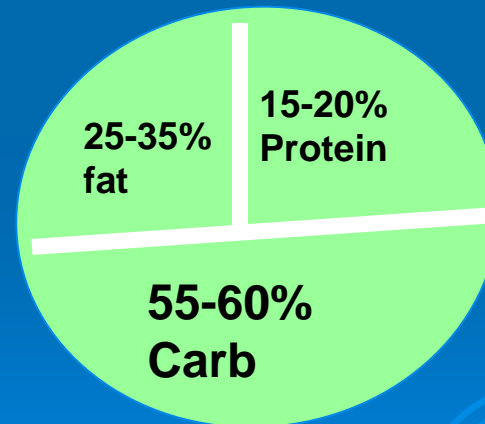


Table 11-3 Grams of Carbohydrate Based on Serving Size of Typical Carbohydrate-Rich Foods**Starches—15 grams Carbohydrate per Serving (80 kcal)****One Serving**

½–¾ cup dry breakfast cereal*	¼ large baked potato
½ cup cooked breakfast cereal	¼ bagel (4 ounces)
½ cup cooked grits	½ English muffin
½ cup cooked rice	1 slice bread
½ cup cooked pasta	¾ oz pretzels
½ cup baked beans	6 saltine crackers
½ cup cooked corn	1 pancake, 4 inches in diameter
½ cup cooked/dry beans	2 taco shells (add 45 kcal)

Vegetables—5 grams Carbohydrate per Serving (25 kcal)**One Serving**

½ cup cooked vegetables
1 cup raw vegetables
½ cup vegetable juice
Examples: carrots, green beans, broccoli, cauliflower, onions, spinach, tomatoes, vegetable juice

Fruits—15 grams Carbohydrate per Serving (60 kcal)**One Serving**

½ cup canned fruit or berries	17 grapes (small)
½ cup fruit juice	½ grapefruit 1½ figs (dried)
1 small apple or orange	3 dates
8 apricots (dried)	1 peach
1 small banana	1¼ cups watermelon cubes

Milk—12 grams Carbohydrate per Serving**One Serving**

1 cup milk	1 cup soymilk
½ cup plain low-fat yogurt	

Sweets—15 grams Carbohydrate per Serving (variable calories)**One Serving**

2-inch square typical slice of cake	½ cup ice cream
2 small cookies	½ cup sherbet

Modified from *Exchange Lists for Meal Planning* by the American Diabetes Association and American Dietetic Association, 2003, Chicago, American Dietetic Association.

*Note that the carbohydrate content of dry cereal varies widely. Check the labels of the ones you choose and adjust serving size accordingly.

During Competition Nutrition

- CHO's are utilized during prolonged exercise
- This means high intensity exercise that lasts 60 minutes or more
- Helps maintain blood glucose levels

Carbohydrates *

➤ As energy sources

- Blood glucose
- Liver glycogen - greatest concentration of glycogen
- Muscle glycogen - greatest amount of CHO's
- Total body storage of CHO's - @1,800 - 1,900 calories
- Gluconeogenesis occurs when glucose is formed by fat or protein

Total Energy Stored as Carbohydrates in The Body

➤ Blood glucose:

- 5 grams or 20 Calories
- Stores may be replenished from liver glycogen or absorption from the intestine

➤ Liver glycogen

- 75-100 grams or 300-400 Calories
- Liver glycogen content may be decreased by starvation or increased by diet

Total Energy Stored as Carbohydrates in The Body

- Muscle glycogen
 - 360 grams or 1,440 Calories
 - 12 grams/kg muscle tissue
- Muscle glycogen stores may be increased or decreased
- Total body storage of carbohydrate is only 1,800-1,900 Calories

Carbohydrates *

- At rest CHO supply total body energy needs
- As exercise becomes more intense CHO is the preferred energy source
- CHOs are the only fuel that can be used for anaerobic energy production
- Most efficient fuel for aerobic - produces ATP three times more rapidly than fat

Carbohydrates

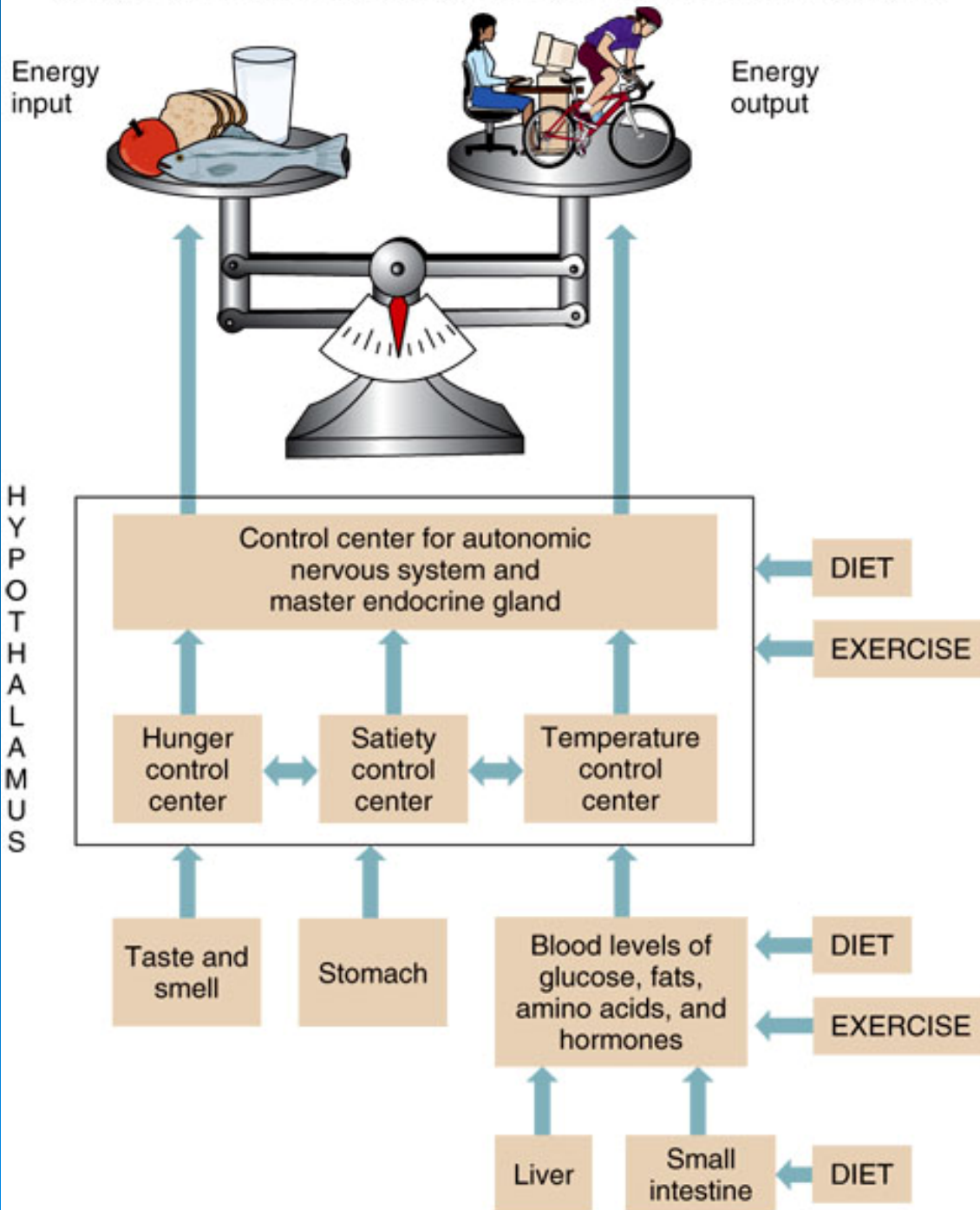
➤ Hypoglycemia

- Occurs when there is a depletion of liver glycogen
- Body wants to maintain an optimal blood glucose level so hormones are released to aid in this:
- Epinephrine is secreted from the adrenal gland and stimulates liver to release glucose
- Glucagon is released from the pancreas and increases rate of gluconeogenesis from the liver
- Cortisol is secreted from the adrenal gland and helps the breakdown and release of amino acids from muscle tissue to provide a substrate to the liver for gluconeogenesis

Carbohydrates *

➤ Hypoglycemia

- Low intensity exercise - gluconeogenesis helps maintain blood glucose above hypoglycemic levels
- Normal blood glucose is 80-100mg glucose per 100 ml of blood
- Hypoglycemia is 45 mg glucose per 100 ml of blood
- CHO consumption during prolonged exercise helps minimize this



CHOs and Exercise *

- < 30 minutes - CHO supplementation will not increase performance
- High intensity resistance training - CHO supplementation will not increase performance
- 60-90 minutes of high intensity exercise - CHO supplementation will increase performance
- > 90 minutes - CHO supplementation will increase performance

CHOs and Timing *

- Eating CHOs 4 hours or less before exercise - increases performance
- < 1 hour may be beneficial if the individual is not hypoglycemic
- Immediately before performance - no benefits
- During exercise of prolonged duration will help maintain blood glucose levels



Carbohydrate Needs

- Main fuel for many types of activity
- Consume ~60% of total kcal from carbohydrate
- Adhere to the Food Guide Pyramid
- ≥ 5 gm of carbohydrate/kg body weight
- Aerobic and endurance athletes
 - 7-10 gm carbohydrates/kg body weight
 - ~ 500-600 gm of carbohydrates/day

Maintaining Normal Blood Glucose Level *

- Intake of 30-60 gm carbohydrates per hour
 - During strenuous endurance activity
 - Delays fatigue by 30-60 minutes



30- 60 Grams of Carbohydrate *

➤ Equivalent to:

- 4 oz juice and a small banana = 30 grams
- 8 oz milk (12grams) and a medium apple =30grams
- 1 large bagel =60 grams
- 8 Tbsp of raisins =60grams



Carbohydrate Servings

<u>Food Group</u>	<u>gm CHO/svg</u>	<u>Svg Size</u>
Starches	15 grams	1 slice bread 1/3 C rice or pasta 1 small potato
Fruit	15 grams	1/2 banana 15 grapes 4 oz juice
Milk	15 grams	8 oz milk 6 oz light yogurt

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Products Marketed To Athletes

- Sport drinks: Gatorade, PowerAde (14 to 18 grams per 8 ounces)
- Sport gels (20-30 grams of carbohydrate)
 - Relode, GU, PowerGel, Clif-Shot
- Sports bars (19-50 grams of carbohydrate)



Table 11-6 Calorie and Macronutrient Contents of Popular Energy Bars and Gels

Product	Calories (kcal)	Carbohydrates (grams)	Protein (grams)	Fat (grams)
PowerBar Performance (chocolate)	230	45	10	2
PowerBar ProteinPlus (cookies & cream)	230	38	24	5
PowerBar PowerGel (lemon lime)	110	28	0	0
Luna Bar (cherry-covered chocolate)	180	28	10	4
Clif Bar (chocolate chip)	250	45	10	5
Clif Shot (viva vanilla)	100	24	0	0
Balance Bar (chocolate)	200	22	14	6
Balance Satisfaction (chocolate crisp)	280	47	12	6
Boulder Bar (chocolate)	210	42	10	4

Overall, choosing energy bars is preferable to choosing candy bars and packaged cakes. When used in sports situations, energy bars can be handy. Better yet, however, is to eat a variety of wholesome foods; these offer more health-protective compounds. This is also a less expensive choice, especially for day-to-day snacking. An additional concern is that micronutrient toxicity might occur if numerous bars are eaten in a day, as many are highly fortified. Vitamin A and iron are two nutrients of special concern in this regard.

Factors that Might Impair Exercise Performance

- Rapidity with which the carbohydrate leaves the stomach
- Impact on the absorption of water
- Dumping syndrome-high concentrations of simple sugars, particularly fructose, exert a reverse osmotic effect in the intestines
- Lactose

Carbohydrate Consumption Before or During an Event And Performance

➤ Initial endogenous stores

- If normal, feedings are unnecessary for continuous exercise work bouts lasting 60-90 minutes or less
- Critical point is to consume substantial amounts the day or two prior to the event and decrease duration and intensity of training

CHO & Exercise Intensity and Duration

- Carbohydrate supplementation will not enhance performance in high-intensity exercise bouts less than 30 minutes unless they could ameliorate a deficiency
 - No data to support increased performance in very high-intensity resistance exercise training

CHO & Exercise Intensity and Duration

- High-intensity exercise between 30-90 minutes
- Normally supplements have not been found to improve exercise performance
- Supplementation may benefit well-trained athletes who may be able to exercise at high intensity for about an hour

Carbohydrates

- Solid and Liquid Carbohydrates: In her review, Ellen Coleman noted that solid and liquid forms of carbohydrate were equally effective in maintaining blood glucose levels and enhancing exercise performance.
- Peters and others noted that triathletes who consumed a liquid form of carbohydrates performed better on a 3-hour cycling-running exercise task when compared to both a placebo trial and a trial in which the triathletes consumed isocaloric semi-solid carbohydrate foods (orange juice, white bread, marmalade, and bananas).

Will a High-carbohydrate Diet Enhance My Daily Exercise Training?

- Most scientists and sport nutritionists who study carbohydrate metabolism in athletes recommend a high carbohydrate diet for most athletes, particularly endurance athletes, because success in athletic competition is contingent upon optimal training, and for the endurance athlete, optimal training may be contingent upon adequate nutrition, primarily the ingestion of sufficient carbohydrate every day.



Carbohydrate Loading

- The amount of carbohydrate stored in the body is limited, muscle and liver glycogen depletion could be factors that may limit performance capacity in distance events characterized by high levels of energy expenditure for prolonged periods.
- Carbohydrate loading, also called glycogen loading and glycogen supercompensation, is a dietary technique designed to promote a significant increase in the glycogen content in both the liver and the muscles in an attempt to delay the onset of fatigue.
- It is generally used for 3-7 days in preparation for major athletic competitions. *pg 135 for further reading.*

Carbohydrate Loading

- Events lasting longer than 60-90 minutes
- Maximize glycogen stores
- Tapering of exercise while increasing carbohydrate intake
- Additional water weight - up to 2-3 pounds

Carbohydrate Loading Protocol

- Studies show that an appropriate carbohydrate loading protocol, compared to normal or low dietary carbohydrate intake, will substantially increase muscle glycogen levels.
- Glycogen content in the muscle has been reported to increase about two to three times beyond normal and liver glycogen content nearly doubled following a carbohydrate loading regimen, and this increase may last at least 3 days in a rested athlete.
- However, it may be important to taper and rest about 2 days prior to the event.
- Approximately 3 grams of water are bound to each gram of stored glycogen. If your body stores an additional 300-400 grams of glycogen, along with 900-1200 grams of water, your body weight will increase about 1200-1600 grams, or 2.5-3.5 pounds above your normal training weight during the loading phase.

Carbohydrate Loading

- Good for long distance athletes - cycling, runners, swimmers, triathletes, tennis, soccer
- Consuming a high CHO diet during training will help the body metabolize CHOs during the loading phase
- Excess calories can be converted into body fat!
- Complex CHOs have higher nutrient value
- Last large meal - 15 hours before race time

What Type of Athlete Would Benefit from Carbohydrate Loading?

- Carbohydrate loading is for those individuals who will sustain high levels of continuous energy expenditure for prolonged periods
 - Long distance runners, swimmers, bicyclists, triathletes, cross-country skiers, and similar athletes.
 - Athletes who are involved in prolonged stop-and-go activities, such as soccer, lacrosse, and tournament-play sports like tennis and handball.
- Athletes who compete in sports involving high-intensity, short-duration, energy expenditure will not benefit from carbohydrate loading.
- Long, continuous exercise depletes glycogen principally in the slow-twitch red and fast-twitch red fibers, whereas fast, intermittent bouts of exercise with periods of rest, actually a form of interval training, primarily deplete glycogen in the fast-twitch white fibers.

How Do You Carbohydrate Load?

- The key to carbohydrate loading is to switch from the normal, balanced diet to one very high in carbohydrate content.
- It first involved a glycogen depletion stage induced by prolonged exercise and a restricted diet. However, this original method may be particularly difficult to tolerate, especially if one tries to exercise at high levels during the depletion phase.
- Also prolonged exhaustive exercise may lead to muscle trauma, which may actually impair the storage of extra glycogen.

How Do You Carbohydrate Load?

- Recent data suggest that this strict routine may be unnecessary, particularly the total program of depletion.
 - For example, in trained runners, research has shown that simply changing to a very high-carbohydrate diet, combined with 1 or 2 days of rest or reduced activity levels (tapering), will effectively increase muscle and liver glycogen.
 - Well-controlled research has revealed that exhaustive running is not necessary to achieve muscle glycogen supercompensation. It appears to be important to continue endurance training, or other high-intensity training specific to the sport, during the 7-14 days prior to competition.
- Evidence also suggests that if the total carbohydrate content is consumed over the entire week, in contrast to concentration it in 2-3 days, there will be little difference in the muscle glycogen content between the two techniques.

How Do You Carbohydrate Load?

- The high-carbohydrate diet should contain about 8-10 grams of carbohydrate per kilogram of body weight, or about 400-700 grams per day, depending on the size of the individual.
 - This is not too different from the generally recommended dietary content of carbohydrate for the endurance athlete in regular training.
- It is important to note that the athlete should not change his or her diet drastically prior to competition.
- Consuming a high-carbohydrate diet during training will condition the body to metabolize carbohydrate properly during this loading phase.

How Do You Carbohydrate Load?

- Because glycogen loading for long-distance events occurs over 2 to 3 days, it would be wise to stress complex carbohydrates in the diet because of their higher nutrient content.
- The diet should also include the daily requirements for protein and fat.
 - If, for some reason, the athlete cannot carbohydrate load over the 3-7 day period, a rapid protocol may be effective.
- Most prolonged endurance events begin in the morning. The last large meal should be about 15 hours prior to race time, possibly topped off with a simple carbohydrate snack before retiring for the night.
- A carbohydrate breakfast such as orange juice, toast, jelly, or other carbohydrates along with some protein may be eaten 3 to 4 hours prior to competition.

A Recommended method	Original Classic Method
1 st day: depletion exercise (optional)	1 st day: depletion exercise
2 nd day: mixed diet, moderate carbohydrate; tapering exercise	2 nd day: high-protein/fat diet; low carbohydrate; tapering exercise
3 rd day: mixed diet, moderate carbohydrate; tapering exercise	3 rd day: high-protein/fat diet; low carbohydrate; tapering exercise
4 th day: mixed diet, moderate carbohydrate; tapering exercise	4 th day: high-protein/fat diet; low carbohydrate; tapering exercise
5 th day: high-carbohydrate diet; tapering exercise	5 th day: high carbohydrate diet; tapering exercise
6 th day: high-carbohydrate diet; tapering exercise or rest	6 th day: high-carbohydrate diet, tapering exercise or rest
7 th day: high-carbohydrate diet; tapering exercise or rest	7 th day: high-carbohydrate diet; tapering exercise or rest
8 th day: competition	8 th day: completion

Carbohydrate Loading

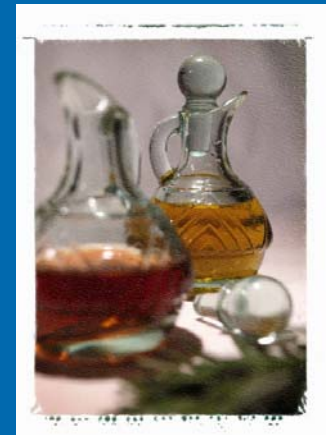
- Although carbohydrate loading may be an effective technique to enhance performance in prolonged aerobic endurance events, research suggests the most effective protocol is to carbohydrate load and use carbohydrate supplements during the event.
- This method appears to be the most appropriate as it will help provide increases in muscle glycogen before exercise, two factors that may be associated with enhancement of endurance performance.

Carbohydrate Loading

- Diabetics should consult with their physician before CHO loading
- Can cause diarrhea, vomiting, nausea, and cramping when diet is changed drastically or increase in consumption of simple CHOs

Carbohydrates as Ergogenic Nutrients

- Truly, carbohydrates represent one of our most important ergogenic nutrients.
- Metabolic by-products of carbohydrate metabolism have been tested as ergogenics.
 - Most have been found to be ineffective, although research with physically trained individuals is rather limited.



Chapter 5 FATS



Lipids

- Composed of C, H and fewer O
- Basic unit is fatty acid
- Triglyceride is the major form of lipid
- Fats and oils
- Unsaturated Fatty Acids
- Saturated Fatty Acids
- Essential Fatty Acids
- Energy yielding (9 kcal /gm)



Lipids/Fats

- The major source of fats :
- Triglycerides, phospholipids, and cholesterol.
- Triglycerides are in the storage form of fat
- Phospholipids are part of the cell membrane
- Cholesterol: found in foods & made in the body

Fats

➤ Lipids

- Triglycerides
 - “true fats” - eaten and stored in the human body
 - Glycerol + fatty acids
 - Fatty acids
 - Saturated - solid at room temperature
 - Monounsaturated, Polyunsaturated
 - Partially hydrogenated -” trans fats”
- Cholesterol - made naturally in animal livers
- Phospholipids - lecithin

Fats

➤ Form body structures

- The structure of almost all cell membranes consist of phospholipids and cholesterol

➤ Help regulate metabolism

- Essential fatty acids - involved in regulation of gene expression
- Cholesterol is a component of testosterone and estrogen
- Cholesterol - used to produce bile salts

➤ Source of energy

- Triglycerides break down into free fatty acids and glycerol. The Free Fatty Acids (FFAs) are used to produce energy.
- Glycerol used by liver to form glucose or other lipids.

Fats

- Triglycerides - stored in adipose tissue has 80,000 - 90,000 calories of energy in average adult male with normal body fat
- Greatest amount of energy stored in the body *

Fat Needs

- ~35% of total kcal
- Rich in monounsaturated fats
- Limit saturated fats
- Limit *trans* fat

Goals for the Healthy North American Diet

- Less than 30 percent of total caloric intake
- Less than 10 percent of total intake as saturated fat
- 10-15 percent of total calories from monounsaturated fat
- No more than 10 percent of total Calories as polyunsaturated fat
- Omega-3 fatty acid intake should be increased

Types of Fats

- **Saturated Fats:** Mostly animal sources, Increase your bad cholesterol (LDL)- Butter, Animal Fat, Palm and Coconut Oils
- **Hydrogenated/trans fatty acids:** act like saturated fats and can be found in stick margarine, solid shortening, and many pastries, muffins, pies and donuts

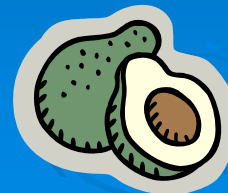
Unsaturated Fats: Liquid at Room Temperature *

➤ Polyunsaturated fats: Can lower your good cholesterol (HDL) but still lower your bad cholesterol (LDL):

- include corn oil, safflower oil, soybean oil, cottonseed oil, some salad dressing, many fried foods and chips, crackers and cookies, fish oils

➤ Monounsaturated fats: Increase your HDL and lower your bad cholesterol (LDL):

- include canola oil, olive oil, peanut oil, olives, most nuts, & avocado



Fat Needs

- Little or no trans fats
 - Partially hydrogenated
- < 10% saturated fats
 - Animal fats, dairy
- 10-15% monounsaturated fats
 - Olive oil
- ~10% Polyunsaturated fats
 - Nuts, fish, soy products

Fats

➤ Two major energy sources

- Plasma free fatty acids
 - In short supply
 - Replenished by triglycerides stored in adipose tissue
 - FFAs transported to mitochondria and goes through Krebs cycle to produce energy
 - Used at low to moderate intensity exercise
- Fatty acids from muscle triglycerides
 - Used increasingly as exercise intensity increases up to 65% of VO_2 max. *
 - > 65% glycogen is the preferred energy source and fatty acids less/or equal to 25% *

Fat Fuel (Fatty Acid)

- Majority of stored energy in the body
- Fatty acids
 - Converted to ATP by muscle cells
- 12 ATP produced
 - Per each turn of the Citric Acid Cycle
 - 108 ATP for each 16 C fatty acid chain
- Trained muscles
 - Have more mitochondria
 - Have greater ability to use fat as fuel

Fat Fuel *

- Rate of fat use
 - Dependent on concentration of fatty acids in the bloodstream
- Prolonged exercise
 - Fat becomes main fuel source
- Intense activity
 - Fat is not a major source of fuel
 - Requires more oxygen for aerobic breakdown (than glucose)

Fat Fuel *

- Trained athletes use more fat as fuel than untrained athletes:
 - Increased blood flow and capillarization to the muscle means more plasma FFAs are delivered
 - Increased # and size of mitochondria for processing of activated FFA
 - Increased FFA release to the plasma and w/in muscles from TGs due to increased sensitivity of adipose and muscle cells to epinephrine
 - Endurance athlete becomes a “fat burner”

Can the Body Make Fat From Protein and Carbohydrate

- Fatty acids are polymers of acetyl CoA
- Amino acids of protein may be converted to acetyl CoA
- Carbohydrates may be converted to fat via acetyl CoA
- There is evidence to suggest that dietary fat may be stored as body fat more readily than carbohydrate or protein
- Fatty acids cannot be converted to carbohydrate or protein

Fats and Exercise

- Fats used as an energy source during exercise
 - The two major sources for the production of ATP during exercise are carbohydrates and fats
 - A mixture of both fuel sources is used during exercise

Sources of Fatty Acids Used by the Muscle Cells During Exercise

- The plasma triglycerides in the chylomicrons and VLDL, less than 10 percent of fat energy
- Plasma FFAs, short supply
- Muscle triglycerides

Fat Energy During Exercise

- Only about 25 percent of the FFA are re-esterified
- Epinephrine is secreted during exercise, stimulating the breakdown of adipose cell triglycerides and release of FFA into the blood
- Epinephrine stimulates intramuscular lipases to catabolize the muscle triglycerides into FFA

Fat Energy Sources During Rest

- Most fat energy needs are met by the supply of plasma FFA to the cells
- Fatty acids from the adipose tissues replenish the plasma FFA
- About 70 percent of the FFA released during rest is re-esterified back into triglycerides



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 - Mild to moderate exercise, 25 percent VO_2 max
 - 20 percent or less of total energy cost is derived from carbohydrate
 - 80 percent or more of total energy cost is derived from fat
 - FFA provided by the adipose tissue appears to be the major source

Muscle Triglycerides are Also Used Exercise At 65 Percent VO_2 Max

- Fats and carbohydrates appear to contribute equally
- Plasma FFA and muscle triglycerides contribute equally to the energy derived from fats
- Exercise at 85 percent VO_2 max and above
 - Energy contribution from fats diminishes to 25 percent or less
 - Muscle glycogen becomes the preferential energy source
- Factors that limit the role of FFA as an energy source during high-intensity exercise
 - Inadequate mobilization from the adipose cells
 - Suboptimal intramuscular processes may limit fat oxidation

Fat Energy During Exercise

- Within about 90 to 120 minutes of high-intensity exercise, the body shifts to an increasing usage of FFA, leading to a decrease in exercise intensity
- Recent research suggest women oxidize more fat and less carbohydrate than men when exercising at 65 or 75 percent of VO_2 max
- Effects of exercise training on fat metabolism during exercise

Fat Energy During Exercise

- Trained athletes use more fat than untrained athletes during a standardized exercise task
 - Increased blood flow and capillarization to the muscle, delivering more plasma FFA
 - Increases the muscle triglyceride content
 - Increased sensitivity of both muscle cells and adipose cells to epinephrine
 - Improved ability to use ketones as an energy source
 - Increased number and size of mitochondria and associated oxidative enzymes for processing of activated FFA
 - Increased activation of FFA and transport across the mitochondrial membrane
 - Increased activity of oxidative enzymes

Mild To Moderate Exercise, 25 Percent VO₂ Max

- 20 percent or less of total energy cost is derived from carbohydrate
- 80 percent or more of total energy cost is derived from fat
 - FFA provided by the adipose tissue appears to be the major source
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Exercise at 65 percent $\dot{V}O_2$ max

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Factors that Limit the Role of FFA as an Energy Source During High-intensity Exercise

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FFA and Exercise

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Highly trained endurance athletes may be able to use fats more efficiently at exercise intensity levels greater than 50 percent $\dot{V}O_2$ max



FAT - MCT Supplementation

- MCTs- medium chain triglycerides
- Are they ergogenic?
 - Studies show that they have no ergogenic effect on endurance performance
 - Ingestion of large amounts may lead to GI distress
 - MCT-CHO solution ---> no additional benefits

Fats and Exercise

- Fasting impairs endurance exercise performance
- Medium-chain triglycerides and endurance performance
 - Do not inhibit gastric emptying and may be absorbed rapidly in the small intestine
 - Oxidized at a rate comparable to exogenous glucose
 - MCT supplementation research is promising, more is needed to evaluate the ergogenic potential

Fat loading

- Appears to be no benefit associated with consumption of a high-fat meal several hours prior to performance
- Consuming a high-fat diet for one or two days may impair performance in high-intensity exercise task
- Chronic low-carbohydrate and high-fat diets
 - Do not benefit performance in untrained individuals
 - Additional research is needed with highly-trained endurance athletes
- Based on the best available scientific evidence, the “zone” diet should be considered more ergolytic than ergogenic to performance

Fats: Ergogenic Aspects

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- Based on the best available scientific evidence, the “zone” diet should be considered more ergolytic than ergogenic to performance

Fats: Ergogenic Aspects

- Fasting impairs endurance exercise performance
- Medium-chain triglycerides and endurance performance
 - Do not inhibit gastric emptying and may be absorbed rapidly in the small intestine
 - Oxidized at a rate comparable to exogenous glucose
 - MCT supplementation research is promising, more is needed to evaluate the ergogenic potential
- Glycerol
 - Does not prevent hypoglycemia or muscle glycogen depletion patterns in prolonged exercise tasks
 - Glycerol may be used to increase body water, including plasma volume prior to exercise
 - May improve cardiovascular function
 - May regulate body temperature more effectively

Fats: Ergogenic Aspects

- Studies have not shown that wheat germ oil is an effective ergogenic aid
- Lecithin supplements do not appear to be an effective ergogenic aid

Fats: Ergogenic Aspects

- Why are omega-3 fatty acids suggested to be ergogenic, and do they work
 - Omega-3 fatty acids may elicit favorable physiological effects relative to several types of physical performance
 - They may be incorporated into the membrane of the red blood cell (RBC), making the RBC less viscous and less resistant to flow
 - Prostaglandin E1 (PGE1) may elicit a vasodilation effect on the blood vessels and stimulate the release of human growth hormone
 - These two changes should enhance blood flow benefiting the endurance athlete

Fats: Ergogenic Aspects

- The increased secretion of human growth hormone might stimulate muscle growth and benefit the strength/power athlete and may also facilitate recovery from intense exercise bouts
- There is insufficient data to support an ergogenic effect of omega-3 fatty acids at this time

Can Carnitine Supplements Enhance Fat Metabolism and Physical Performance?

- Theoretically, carnitine would be beneficial for athletes in very prolonged endurance events by increasing the utilization of fatty acids during exercise and sparing the use of muscle glycogen
- It may facilitate the oxidation of pyruvate
- It may increase blood flow both at rest and during exercise
- Carnitine supplementation has been used effectively to improve exercise capability in patients with serious diseases
- D-carnitine may be toxic; L-carnitine appears to be a safe supplement at levels of no more than 2-5 gr/day

Key Points Regarding the Ergogenic Effects of Carnitine Supplementation

- Supplementation will increase plasma levels of carnitine, but much of this will be excreted by the kidney
- Acute supplementation does not appear to enhance performance
- Chronic supplementation has no effect on lactic acid accumulation during high-intensity anaerobic exercise, nor does it increase performance in such exercise tasks
- The effect of chronic carnitine supplementation on VO_2 max is equivocal, but most reviewers believe it has no significant effect
- theory underlying carnitine supplementation is enhanced fat utilization which does seem to occur
- D-carnitine may be toxic; L-carnitine appears to be a safe supplement at levels of no more than 2-5 gr/day

Fats Ergogenic Aids

- Studies have not shown that wheat germ oil is an effective ergogenic aid
- Lecithin supplements do not appear to be an effective ergogenic aid



Glycerol

- Does not prevent hypoglycemia or muscle glycogen depletion patterns in prolonged exercise tasks
- Glycerol may be used to increase body water, including plasma volume prior to exercise
 - May improve cardiovascular function
 - May regulate body temperature more effectively

Next Week: Full Agenda

➤ Proteins

- Functions
- Diet Needs
- Safety
- Supplements
- Effects on Performance
- Creatine
- Branched Chain Amino Acids
- Glutamine
- Chondroitin and Glucosamine

➤ Water, Key Electrolytes and Hydration

