SPORT
MEDICINE MANUAL

13

NURITION

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NUTRITION

13

A. The Fundamental Elements of the Athlete's Diet

The human body requires more than 50 essential nutrients on a daily basis. A variety of different foods must be consumed on a regular basis in order to obtain these essential nutrients. In general, the athlete's diet should conform to the basic dietary guidelines for a healthy, balanced diet developed by National Health Departments for the general population, with some adjustments (increases) for total energy supply, carbohydrates, proteins and fluids.

Table 13.1 The Six Nutrient Categories and Their Subgroups.

Carbohydrates		**Proteins**	**Fats**		**Vitamins**		**Minerals**	**Water**
Simple	Complex	Amino Acids	Saturated	Unsaturated	Water Soluble	Fat Soluble		

1. The Athlete's Training Diet Must Include

Energy - Adequate dietary kilocalories (carbohydrates, fats, protein) must be consumed to meet the energy demands of training, competition, and to maintain body weight. Energy requirements are determined by the athlete's basal metabolism (related to age, gender, body composition), diet-induced thermogenesis and physical activity (related to exercise intensity and volume). For athletes, daily energy expenditure values in excess of 4,000 kilocalories are not uncommon. If energy requirements are met through the consumption of nutrient rich foods, there is little likelihood of developing nutrient deficiencies.

Carbohydrates - A high carbohydrate intake (55-60% of total kilocalories (kilojoules)) is needed to provide adequate energy for optimal performance. A minimum of 5 grams of carbohydrate per kilogram body weight should be consumed daily. Some athletes may require carbohydrate consumption upwards of 10 grams per kg body weight per day to meet their energy demands. Energy needs depend on the athlete's age, gender, and body weight, and increase in proportion to exercise intensity and volume.

Protein - Sufficient protein is essential for muscle maintenance, tissue repair and production of antibodies to fight infection. Approximately 12-15% of total kilocalories (kilojoules) should be derived from dietary protein. More specifically, sedentary individuals require 0.8-1.0 gram of protein per kg body weight per day. Endurance athletes may need 1.2-1.6 grams of protein per kg body weight per day. Strength-trained athletes require protein in the range of 1.4-1.8 grams per kg body weight per day. Excess dietary protein beyond these levels is not necessary for gains in muscle mass. Surplus dietary protein may lead to dehydration, osteoporosis and body fat storage.

Fats - A low-fat diet [25-30% of total kilocalories (kilojoules)] is necessary to facilitate adequate carbohydrate intake. Although fat is an important substrate for energy production, large intakes are unnecessary. Even very lean athletes usually have significant body fat stores. Excess dietary fat consumption delays digestion thereby creating a “heavy” stomach sensation causing lethargy, and interfering with adequate CHO intake.

Variety - A variety of foods are essential to obtain the necessary vitamins and minerals (refer to the table later in this unit that indicates vitamin dietary sources and functions).

Fluids - Adequate fluids must be consumed to maintain proper hydration. Fluid losses during hard exercise in the heat may be as high as 2-3 litres per hour. Rehydration after exercise should exceed the volume of fluid lost to compensate for the ongoing obligatory urinary losses.

2. Carbohydrates

Dietary carbohydrates (CHO) provide the best source of food energy for physical activity. One gram of CHO supplies 4 kilocalories. Both the simple and complex CHO contain insoluble and/or soluble dietary fibre.

Table 13.2 Carbohydrate sources.

Carbohydrate Type	Number of Glucose Molecules	Sources
Simple "Sugars"	1 or 2	Breads, cereals, rice, grains (bulgar, millet, barley, oats, kasha, couscous), pasta, potatoes, maize, peas, legumes (dried peas, beans, and lentils), yams, squash Also includes sugar alcohols - xylitol, mannitol, and sorbitol
Oligosaccharides	3-9	Maltodextrins often found in sport drinks, gels, and sport bars
Complex Carbohydrates - "Starches"	> 9	Fruit, fruit juices, milk, yogurt, jam, jelly, syrup, honey, white sugar, brown sugar

Glycemic Index

For practical reasons, there are many limitations to the use of the glycemic index. The data that is available is largely based on tests using single foods. For example, food combinations do not yield predictable blood glucose responses. In addition, the glycemic index is based on equal grams of CHO, not the average portion sizes, thus limiting its application. However, the glycemic index may be a useful system for selection of carbohydrates for use prior to, during, and after exercise.

Table 13.3 Glycemic Index of Selected Carbohydrate Rich Foods.

High Glycemic Foods	Moderate Glycemic Foods	Low Glycemic Foods
Sugar, honey, molasses Sports drinks (6-10%), Bagels, breads (white & whole wheat), refined cereals, potatoes, corn & raisins	Rice (brown & white), pasta, oatmeal, whole grain rye, bread, grapes, oranges, yams, baked beans, & other dried fruits	Most fresh fruits, legumes, & dairy products (Protein rich foods and sources of dietary fat are low glycemic foods)

Carbohydrate Digestion and Absorption

The small intestine is the main site of CHO digestion and absorption. Carbohydrates must be in the form of a simple CHO before they can be absorbed into the blood stream and carried to the liver, where they are converted to glucose, the main energy source used by the body. Blood glucose levels must not get too high (hyperglycemia) or too low (hypoglycemia), otherwise adverse physical symptoms of weakness, dizziness and nausea may result. Blood glucose can be converted to liver or muscle glycogen for storage, or it can be used for immediate energy by muscles, brain, heart, kidneys and other tissues.

A 68 kg (150 lbs) active male stores approximately 1,800 kilocalories as Carbohydrate:

Muscle Glycogen	350 grams CHO
Liver Glycogen	80 grams CHO
Blood Glucose	20 grams CHO
TOTAL	450 grams CHO x 4 kilocalories per gram = 1,800 kcal

Carbohydrates and Exercise Metabolism

- Glucose is the preferred energy source for the healthy functioning of every cell.
- The availability of CHO for energy limits the use of protein as fuel, thus allowing proteins to be used for cell maintenance, tissue synthesis and other essential functions.
- Carbohydrates facilitate the complete combustion of fat in the body's energy releasing processes.
- A high CHO diet is associated with both a higher initial muscle glycogen concentration and greater endurance in athletes, compared to a high fat or normal mixed diet. A high CHO diet (65-70% of total energy or regular consumption of 7-10 grams of CHO per kg body weight per day), is recommended for endurance athletes or athletes in heavy training.
- Recreational athletes and most active individuals should strive for a diet composed of 55-60% of energy as CHO.
- Approximately 2 to 4 hours of moderate to high intensity exercise could deplete carbohydrate stores. It is possible that low glycemic foods may offer an advantage when eaten before endurance exercise because they provide a slow release of glucose into the bloodstream.
- For events lasting longer than 90 minutes, or for shorter events that are repeated during a single day, athletes should consume 40-70 grams of CHO during each hour of exercise to delay hypoglycemia, glycogen depletion and possible fatigue. The baseline level of pre-exercise muscle glycogen may also be critical in predicting the value of CHO intake during

exercise.

- Both liquid and solid CHO feedings are equally effective in glycogen repletion following exercise. A high CHO beverage may be the preferred CHO choice for nutritional recovery because it is rapidly digested and absorbed, as well as encourages rehydration. High and moderate glycemic foods may be advantageous to provide a rapid release of glucose into the bloodstream. Carbohydrate foods containing predominantly fructose, ie. fruit and fruit juices which have a low glycemic index, may delay the rate of glycogen repletion.
- Carbohydrates should be consumed immediately after and at frequent intervals following exercise to optimize muscle glycogen repletion. The glycogen resynthesis rate is maximal with a CHO ingestion of approximately 0.7-1.0 grams CHO per kg body weight per hour following exercise.

3. Proteins

A major function of protein is to provide the structure, maintenance and repair required for many body tissues, eg. muscles, tendons, and ligaments, and for the production of haemoglobin, enzymes, hormones and antibodies. A secondary function of protein is to provide a source of energy when carbohydrate and fat are not accessible or available in adequate amounts. This usually occurs under starvation conditions, with very low energy diets, and when carbohydrate reserves are exhausted.

As a result of regular exercise, protein needs are increased due to the following mechanisms:

- protein is degraded and may be used as an energy source
- protein is needed for muscle building in response to resistance training
- protein is needed to facilitate exercise recovery (ie. tissue repair)

Protein Requirements

To accommodate the protein needs of training, 12-15% of total energy intake should be derived from dietary protein. Strength-trained athletes may require 1.4-1.8 grams of protein per kg body weight per day, while endurance trained athletes may suffice with 1.2-1.6 grams of protein per kg body weight per day.

Complete amino acid supplements are often promoted to athletes as being better absorbed than intact protein from the diet. There is no evidence that free amino acids are absorbed more rapidly than whole proteins. Amino acid supplements are often unpalatable, can cause gastrointestinal upset (nausea, cramping and diarrhea) and are extremely costly. Single amino acid supplementation can interfere with the absorption of essential amino acids and may therefore lead to nutritional imbalances. Most individual amino acid supplements contain insufficient quantities to stimulate an anabolic effect.

High Protein Diets

Many side effects can be associated with high protein diets including:

- increased renal function to metabolize ammonia
- increased urine production to excrete ammonia, hence dehydration
- higher fat intake
- increased urinary calcium excretion, hence bone mineral density may be negatively affected
- compromised carbohydrate consumption
- higher financial costs, since protein rich foods are often expensive

Table 13.4 Protein Quality.

High Quality, Complete Sources of Protein	Low Quality, Incomplete Sources of Protein
Eggs, meat, poultry, fish, milk and milk products	Legumes (dried peas, beans and lentils), soy and soy products, nuts, cereals, grains

4. Fats

Fat is a concentrated source of energy, providing 9 kilocalories per gram, more than twice the energy per gram as carbohydrate and protein. In addition to its function as a fuel, fat also has a thermoregulatory and cushioning effect through body insulation (subcutaneous, intramuscular, and surrounding vital organs). Fat is necessary for the production of essential fatty acids (linoleic, linolenic and arachidonic), for the absorption of fat soluble vitamins (A, D, E, and K), as well as for hormone synthesis.

Sources of Dietary Fat

Dietary fats are derived from animal and plant sources. The fat in animal products is primarily saturated. Plant sources of fat are naturally unsaturated (polyunsaturated and monounsaturated), with the exception of saturated fats from palm oil, palm kernel, coconut oil, vegetable shortening and hydrogenated oils. Cold water fish also contain unsaturated fat. Cholesterol is another type of dietary fat, and it is also produced by the body. Dietary sources of cholesterol only include animal products.

Table 13.5 Sources of Dietary Fats.

Cholesterol	Saturated	Unsaturated
Eggs, organ meats, meats, poultry, seafood, dairy products	Eggs, meats, poultry, fish, dairy products, palm oil, palm kernel oil, coconut oil, vegetable shortening, hydrogenated oils	Vegetable oils - olive, safflower, sunflower, soybean, corn, and canola; peanut oil, avocados, cold water fish

Digestion and Absorption of Fat

Dietary fats must be broken down into fatty acids before they can be absorbed. The bloodstream carries fat to the various tissues including liver, heart, muscle and adipose tissue where it is either stored or used for energy. Since the digestion and absorption of fats is a multi-step process, fats take a longer time to digest than carbohydrates and proteins. Fats are not completely absorbed from the small intestines for at least four hours after a meal. As a result, dietary fats may delay the feeling of hunger and will slow the absorption of carbohydrates and proteins. Therefore a moderate amount of dietary fat may be useful prior to endurance events (eg. cycling, cross country skiing).

Fats and Exercise Metabolism

- Energy production during athletic activity, especially intense activity, is primarily dependent on the presence of available carbohydrates. Thus when carbohydrate supply is reduced, the intensity of the activity must also be reduced.

- The overall contribution of fats to supply energy increases as the intensity of the exercise decreases. The fat mobilized from body fat stores is thought to be greatest at low exercise intensities (25% $\dot{V}O_2$ max.) and shifts more towards use of the fat stored in muscle as the exercise intensity increases (from 25 to 65% $\dot{V}O_2$ max). However, following high intensity exercise, athletes may utilize fat oxidation during recovery.

- One of the adaptations with endurance training is the increased capacity of the skeletal muscle to use fat during exercise. Therefore, fat serves as an important fuel for endurance events when trained athletes perform at low exercise intensities.

- A low fat intake may be necessary to ensure high carbohydrate consumption.

- Since fats are more slowly digested than carbohydrates and proteins, pre-event nutrition should entail a low-fat meal or snack.

- In general, athletes should derive 25-30% of their total energy from fat, with no more than 10% of total energy as saturated fat.

Critical Fat

Although excess body fat is undesirable, a minimum level of critical body fat (essential fat and subcutaneous body fat) is necessary for maintaining good health. Decreased exercise performance, lowered disease resistance, delayed wound and injury repair, plus menstrual irregularities and amenorrhea may result when the athlete has insufficient body fat. Body fat levels range from 3-15% for male and 10-25% for female athletes. The average healthy range of body fat for sedentary individuals is 15-22% for men and 18-32% for women. The amount of essential, critical body fat is 3% for men and 12% for females. (see Unit 12 E - Body Composition and Anthopometry).

Reduction of Dietary Fats

For those athletes who may benefit from a reduction in dietary fat, their efforts should include minimizing the added fats (butter, margarine, oils, salad dressings), the consumption of high fat snacks (chips, chocolate bars, nuts), and choosing lean proteins and low fat dairy products.

5. Vitamins and Minerals

Vitamins serve as part of enzyme systems to regulate bodily functions. Vitamins alone do not provide energy, but they play a role as coenzymes in the oxidative processes of cells to release energy necessary for athletic activity. Minerals (including electrolytes) are present in the body in relatively small amounts. Metabolically, minerals have regulatory roles as well as providing structure for the formation of bones, and teeth.

Table 13.6 Water soluble vitamins: dietary sources and functions.

Water Soluble Vitamins	Some Dietary Sources	Functions
Thiamin (B1)	Liver, pork, meat, wheat germ, whole grains, enriched grains, legumes, nuts	Nervous system function CHO metbolism
Riboflavin (B2)	Milk and milk products, liver, enriched grains	Promotess good vision and healthy skin; CHO metabolism
Niacin (B3)	Liver, poultry, fish, nut butters, legumes, mushrooms	Promotes healthy skin, nerves and GI tract CHO metabolism Fat synthesis
Pyridixine (B6)	Liver, fish, wheat germ, whole grains, meats, legumes, bananas	Red blood cell formation Protein and fat metabolism
Cobalamin (B12)	Meat, fish, poultry, eggs, milk products, some specially fermented yeasts, fortified soy products	Red blood cell formation Maintenance of nerve tissue Energy metabolism
Biotin	Organ meats, mushrooms, legumes	Synthesis of fat, glycogen Amino acid metabolism
Pantothenic Acid	Eggs, liver, wheat bran, nuts, legumes, meat, spinach, & other vegetables	Energy and tissue metabolism
Folic Acid (Folacin, B9)	Liver, wheat bran, whole grains, spinach & other dark green leafy vegetables, legumes, nuts	Promotes red blood cell formation Regulates tissue processes CHO and protein metabolism
Vitamin C	Citrus fruits, berries, kiwi, cantalope, tomatoes, broccoli, potatoes, cabbage, sweet peppers	Promotes bone and wound healing Aides in resistance to infections - antioxidant properties

Table 13.7 Fat soluble vitamins: dietary sources and functions.

Fat Soluble Vitamins	Some Dietary Sources	Functions
Vitamin A	Liver, egg yolk, dairy products, carrots, squash, sweet potatoes, broccoli, spinach, peppers, cantalope, mango, papaya, apricots	Maintains health of eyes and skin Aids in resistance to infections - antioxidant properties
Vitamin D	Fortified milk and soy products, cereals, eggs	Aids in absorption of calcium
Vitamin E	Wheat germ, vegetable oils, nuts, seeds	Antioxidant properties Protects vitamins and fats from destruction
Vitamin K	Cabbage, cauliflower, leafy green vegetables	Needed for blood clotting

6. Hydration

Water is most critical to exercise performance and is the nutrient most often neglected by athletes. During exercise, fluid losses are primarily due to sweating and breathing. Approximately 1 litre of fluid intake is necessary for every 1,000 kilocalories consumed. However, additional factors may necessitate an increase in this fluid intake estimation. The greater the exercise intensity, the longer the exercise duration, the higher the humidity and temperature, the greater the fluid loss.

If fluid losses are not replaced, performance will deteriorate. As little as 1-2 % loss of the athlete's body weight from dehydration can jeopardize aerobic performance. There is less evidence that this level of dehydration has negative effects during anaerobic or strength exercises. The following table presents a summary of the effects of dehydration on performance and selected physiological variables when a 3-4 % loss of body weight has occurred as a result of dehydration during exercise.

Table 13.8 Effects of dehydration on performance.

Variable	Performance Effect From Dehydration
Strength	possibly decreased
Maximal speed	possibly unaffected
Reaction time	slight increase
Aerobic endurance	decreased
Anaerobic capacity	decreased
Anaerobic power	decreased
Sweat rate	decreased
Rate of fluid absorption	decreased
Skin blood flow	decreased
Capacity to dissipate heat	decreased
Core temperature	increased
Heart rate	increased
Blood lactate concentration	increased
Maximum oxygen consumption	decreased

Fluid Recommendations

- 500 ml of fluid should be consumed 2 hours before training or competition.
- 150-300 ml of fluid is recommended every 15-20 minutes during exercise; the rate of fluid absorption varies among individuals, but usually ranges between 10-15 ml per kg body weight per hour during exercise.
- Greater quantities of fluid will be needed when exercising in hot and/or humid environmental conditions.
- During exercise, the sensation of thirst is not a good indicator of an athlete's need for fluid; thirst during exercise may represent a 2% loss of body weight.
- During exercise, consumption of a beverage containing a 4-8% carbohydrate concentration (ie. 40-80 grams carbohydrate per 1,000 ml) provides fluid and exogenous energy without compromising fluid absorption, provided that fructose is not the predominant carbohydrate source.
- Following exercise, rehydrate with 1,000 ml of fluid per kilogram of body weight lost from activity, with an additional 250-500 ml to compensate for urinary losses.
- Fluids that are flavoured, lightly salted, cold (10-12 degrees Celsius), and/or sweetened may stimulate voluntary drinking.
- Sodium, potassium and chloride are the main electrolytes which may be lost in sweat; electrolytes can be replaced by consuming an appropriate sport drink or by adding small amounts of salt to the post-exercise meal along with potassium rich foods (eg. bananas, oranges, citrus juices, most vegetables).
- A well-hydrated athlete may notice that they produce large volumes of urine which is clear and pale in colour.
- Compared to adults, children may need to drink relatively more because they have a slower sweat rate, a smaller surface area to release heat, and a delayed sensation of thirst.

Table 13.9 Amounts of fluids to consume during exercise according to body weight.

Body Weight (kg)	50	60	70	80	90
Amount of fluid per hour (ml)	600	720	840	960	1080
Fluid volume every 15 minutes (ml)	150	180	210	240	270

B. Nutritional Assessment

Sound nutrition is essential for peak performance in sport. While a proper diet will not guarantee success in sport, an inadequate diet can certainly undermine an athlete's training programme and limit maximal performance capacity. In spite of this, for various reasons, many athletes practice poor nutritional habits. A programme of nutritional evaluation must be established to monitor the athlete's dietary status and provide appropriate education and intervention.

A well-nourished athlete has a greater ability to:

- maintain a physically demanding training programme and maximize its training effects
- demonstrate consistent performances in competition
- sustain a high level of mental concentration and alertness
- maximize physical growth and development
- reduce the incidence of illness and speed the recovery from illness and injury
- withstand the rigours of travel and exposure to foreign environments

Nutritional Evaluation

A basic nutritional assessment consists of assessing the dietary intake (including supplements) of the athlete to determine the adequacy of their diet related to their needs. Dietary analysis should include a review of the athlete's food records (typical food intake recorded over a minimum of three days). It may be valuable to assess the athlete's intake during both the training and competition periods.

Information obtained from the nutritional analysis is ideally interpreted in combination with other indicators such as:

- clinical results that may be associated with nutritional status, eg. fatigue, poor immunological function
- biochemical results that may be associated with nutritional status, eg. low ferritin, high cortisol, low vitamin B12
- anthropometric data, eg. height, weight, body fat, lean body mass
- record of the athlete's current training and competition programme, eg. volume and intensity of exercise

Determination of additional lifestyle and health-related factors may need to be considered. For example, the athlete may be living away from home, may be diabetic or have food allergies, or may not be able to afford quality food. The following checklist for athletes may be useful to ascertain nutrition-related issues which may impact on an athlete's nutritional status.

Nutritional Screening Tool

Determine how many "Yes" responses the athlete may identify to assess potential issues impacting their nutritional status: (some of these questions may not necessarily be appropriate for every athlete)

1. Do you participate in an aesthetic or judgmental sport? (eg. gymnastics, synchronized swimming, diving, figure skating, ski jumping, etc) YES or NO
2. Do you compete in a weight-classified sport? (eg. wrestling, light-weight rowing, etc) YES or NO
3. Are you trying to lose weight? YES or NO
4. Are you a vegetarian? YES or NO; If "yes", what kind of vegetarian diet?_____
5. Do you avoid red meat (ie. beef or pork)? YES or NO
6. Are you living away from your family? YES or NO
7. If yes to #6 above, do you have good cooking skills and facilities? YES or NO
8. Do you prepare your own meals and/or snacks? YES or NO
9. Do you avoid any specific foods or groups of foods? YES or NO
10. Are you a diabetic? YES or NO
11. Do you have any food allergies or food intolerance? YES or NO
12. Are you on a budget for your food purchases? YES or NO
13. Do you practice or compete in a hot and/or humid environment? YES or NO
14. Do you regularly travel out of town to train or compete? YES or NO
15. Are you unusually fatigued before, during or after workouts? YES or NO

Establishing a Nutritional Evaluation Programme

A sport nutrition evaluation programme could include a variety of services, such as individual and group nutrition consultations, computerized dietary analysis, resource development (eg. information for travel, restaurant meals, etc), grocery shopping tours, and group/team workshops.

Computerized Dietary Analysis - With the assistance of a computer programme, a dietary analysis can provide precise information regarding the athlete's energy intake and specific composition of their diet, including assessment of carbohydrates, proteins, fats, fluids, vitamins and minerals during training and competition phases. The athlete must accurately record all their food, beverage and supplement consumption over at least a three day period, including one day of the weekend. Ideally the duration of the food record documentation should represent the typical eating patterns of the athlete. The computer analysis can be compared to appropriate standards. While this method of diet analysis has many limitations, the results can serve as an effective screening device and educational tool and lead to useful consultations with a qualified registered dietitian/nutritionist.

Individual and Group Nutrition Consultations - These may be scheduled in conjunction with the results of a computerized dietary analysis. If appropriate, family members or the athlete's coach may attend the consultation. The individual dietary consult will include an assessment of the athlete's eating patterns, supplementation, and lifestyle concerns related to their nutritional status and physiological demands in sport. The athlete's personal nutritional concerns will be addressed during the consultation. Group counselling can also be arranged to provide general nutritional information and interpretation of the nutritional analyses, highlighting any common or specific problems identified. The team manager and coach should be present.

Resource Development - A variety of sport nutrition resources may need to be developed or purchased for a sport team and/or for individual athletes. For example, a team may request nutrition information related to travel to a competition in a foreign country. A team may need assistance regarding food choices in restaurants and fast food outlets.

Group/Team Workshops - The nutrition workshops could address several sport nutrition concerns, such as the training diet, weight gain, weight loss, improving exercise recovery, enhancing the immune system and acquiring food preparation skills, to competition nutrition and supplementation.

C. Competition Nutrition

The following recommendations regarding nutrition practices before, during and after competition may also be applied to the athlete's nutrition on their days of exercise training.

1. Pre-Event Nutrition

The pre-event eating guidelines assume the athlete has been following a sound diet throughout their training. Pre-event nutrition encompasses carbohydrate loading (if applicable), the meal consumed the night before the competition, the immediate pre-event meal or snack and possibly the meal or snack chosen in-between events (if applicable). The objective of pre-event nutrition is:

- to consume easily and quickly digested foods and fluids which are familiar to the athlete
- to top-up muscle and liver glycogen stores
- to assist with adequate hydration
- to prevent hunger and ensure mental alertness by providing blood glucose

Carbohydrate Loading

Carbohydrate loading is recommended to supersaturate glycogen stores of athletes involved in endurance events (longer than 90 minutes) or in multi-event competitions.

- To obtain the greatest super-compensation, training in the three days before an event should be decreased so as to burn fewer calories, and a carbohydrate-rich diet consumed. Glycogen depletion, as a result of exhaustive exercise and/or a low-carbohydrate diet, is discouraged when attempting to carbohydrate load.

- During the final 3 days prior to the event, carbohydrate should be increased to 65-70% of total energy input, by a minimum 500 grams carbohydrate per day, or calculated as 7 to 10 grams of carbohydrate per kg body weight per day. Athletes who have difficulty consuming adequate dietary carbohydrate may need to consider the use of a commercial high carbohydrate supplement, as well as reduce unnecessary dietary fat intake.

- The athlete should increase their fluid consumption by at least 1 litre per day when carbohydrate loading since approximately three pounds (1.4 kg) of water are stored per pound (0.5 kg) of glycogen reserves.

The Night Before Competition

The meal consumed the evening before competition should be eaten 15-17 hours prior to the event to allow for complete digestion. This meal should consist of 65-70% carbohydrate (to top up glycogen reserves), moderate protein, limited fats and plenty of fluids. Alcohol, and excessive caffeinated beverages should be discouraged. This meal should include familiar foods to the athlete and avoid foods which may cause gastrointestinal upset (eg. spicy foods, high fibre foods, and foods which may be gas forming).

Immediate Pre-event Meal or Snack

The meal and/or snack choices immediately prior to a competition will depend on the athlete's individual tolerances, as well as the nature of the activity. The greater the upcoming exercise intensity, the farther in advance the athlete will need to eat, to allow sufficient time for gastric emptying.

The pre-event meal and/or snack should contain 65-70% of total energy as carbohydrate, with minimal dietary fat and limited protein. The primary purpose of this meal is to prevent hunger, ensure mental alertness and to provide immediately available glucose into the bloodstream for the upcoming exercise. The pre-event meal will generally not contribute towards muscle glycogen reserves.

Reactive hypoglycemia may occur with some athletes following the consumption of simple carbohydrates (with the exception of fructose) prior to competition. A source of fructose (ie. fruits), which are low glycemic foods, consumed immediately prior to exercise may provide a quick energy supply into the bloodstream.

The following guidelines may be useful when planning meal times relative to a training session, competition or a series of competitions held on the same day (ie. tournaments, etc):

- allow 3-4 hours pre-event for consumption of a large meal (500-800 kcal or more) with 500-1,000 ml of fluids
- allow 2-3 hours for a smaller pre-event meal (300-500 kcal) with 500-750 ml of fluids
- allow 1-2 hours for a small pre-event snack or beverage selection (< 300 kcal) with 250-500 ml of fluids

Table 13.10 Examples of pre-event meals.

Meal 1:	**Meal 2:**
375 ml cereal, 250 ml milk, 1 fruit, 30 g cheese, 250-500 ml water	250 ml cereal, 250 ml milk, 2 slices toast, 1 egg, 250 ml juice, 250-500 ml water
Meal 3:	**Meal 4:**
2 muffins, 175 ml yogurt, 125 ml fruit salad, 250-500 ml juice, 250-500 ml water	500 ml cooked pasta, 125 ml tomato sauce, 30 ml parmesan cheese, 250 ml tossed salad, 125-250 canned fruit, 250-500 ml water
Meal 5:	**Meal 6:**
250 ml vegetable soup, 85 grams poultry, 250 ml mashed potatoes, 250 ml juice, 1 fruit, 250-500 ml water	2 slices bread, 60 grams poultry, 1 leaf lettuce, 1 fruit, 1 muffin, 125-250 ml juice, 250-500 ml water

2. Nutrition During Competition

The impact that nutrition will have during competition depends on the type of activity. Short duration events will not be severely limited by nutrition-related factors, assuming good nutritional status prior to the event. However, endurance events can be influenced by fluid and carbohydrate intakes before and during the event.

- The athlete should follow the nutrition recommendations outlined in pre-event nutrition to ensure adequate glycogen storage and hydration prior to the competition.

- During exercise there is a progressive shift from muscle glycogen utilization to blood glucose oxidation. Carbohydrate feedings during exercise help to maintain blood glucose concentrations for carbohydrate oxidation.

- High intensity, short duration events, such as sprinting, jumping and throwing, are fueled by immediately available adenosine triphosphate (ATP), creatine phosphate (CP) and glycogen. If the athlete has adequate glycogen reserves prior to the short duration event they will not use all of them during their event.

- For events lasting less than 45 minutes duration, water consumption during the activity would likely suffice. However, fatigue throughout endurance events generally occurs as the carbohydrate reserves (blood glucose and glycogen) become depleted.

- For endurance events exceeding 90 minutes duration, an exogenous supply of carbohydrate (liquid or solid) consumed at a rate of 40-70 grams of carbohydrate per hour of activity may enhance performance by maintaining blood glucose levels when glycogen reserves are low. Liquid and solid carbohydrate feedings consumed during exercise are equally effective to improve endurance by increasing blood glucose levels.

- Consumption of fluids (150-300 ml) at regular intervals (every 15-20 minutes) during the event may help prevent dehydration.

- When the exercise duration exceeds 3 hours and/or the environment is hot and humid, the consumption of electrolytes may be necessary to replenish electrolytes lost in sweat.

Sport Drinks

A 4-8% carbohydrate sport drink (ie. 40-80 g CHO per litre) consisting of glucose and/or glucose polymers with electrolytes (0.5 grams sodium per litre) provides carbohydrate with fluids. Carbohydrate solutions in excess of an 8% concentration may cause gastrointestinal upset. Similarly, a sport drink primarily consisting of fructose is less desirable because of slower absorption and possible gastrointestinal upset. Carbohydrate and sodium within a fluid may improve the palatability and thereby encourage greater consumption.

Alternatively, if the endurance athlete chooses to consume exogenous carbohydrate in a solid form, they must be encouraged to rehydrate with adequate quantities of fluid. The athlete requires 150-300 ml of a cool fluid (10-12^{o} C) consumed every 15-20 minutes throughout the exercise. More precisely, an athlete should consume 10-15 ml of fluid per kg body weight per hour during exercise.

3. Post-Event Nutrition

For rapid exercise recovery, it is important to refuel immediately after the activity. Post-event nutrition is particularly critical during consecutive days of competition and/or training. The goal is to replenish carbohydrate energy reserves (blood glucose, muscle and liver glycogen), to replace fluid and electrolyte losses, and to repair tissue damage from exercise.

- The greater the glycogen depletion from high intensity exercise and/or long exercise duration, the faster the rate of post-exercise glycogen synthesis.

- Active recovery at a moderate intensity (> 40% $\dot{V}O_2$ max) following prolonged exercise may interfere with glycogen synthesis.

Carbohydrate Feedings After Exercise

- Muscle and liver glycogen concentrations can return to pre-exercise levels during the immediate 24 hours after exercise with the consumption of a high carbohydrate diet (>70% kcal) providing approximately 7-10 grams of carbohydrate per kg body weight per day. However, to achieve this repletion of glycogen, adequate dietary carbohydrate (0.7-1.0 gram CHO per kg body weight) must be consumed within each of the two hours immediately after exercise and continue re-fueling at this rate thereafter.

- During the initial hours of recovery after exercise, consumption of liquid or solid carbohydrate feedings are equally effective to promote glycogen repletion. High glycemic carbohydrates (solids or liquids) may be ideal for glycogen repletion. However, the presence of fructose ingestion slows the rate of glycogen synthesis due to the low glycemic index of fructose and the preferential uptake and metabolism of fructose by the liver, relative to skeletal muscle.

- A mixed diet containing ample carbohydrate (with the presence of protein) may elicit a greater insulin response and thus may result in greater glucose uptake leading to faster muscle glycogen synthesis. As well, consumption of dietary protein after exercise helps to supply amino acids for tissue anabolism and repair.

Rehydration and Electrolyte Repletion

Please note comments concerning hydration in section A 6 above.

Sodium, potassium and chloride are the main electrolytes which may be lost in sweat; electrolytes can be replaced by consuming a sport drink or by adding small amounts of salt to the post-exercise meal along with potassium rich foods (eg. bananas, oranges, citrus juices, most vegetables).

D. Nutrition Concerns Related To Travel

Considerations for Air Travel

Most symptoms from jet lag are associated with crossing time zone(s), dehydration from the pressurized aircraft cabin, and from sitting for long periods of time.

Suggestions to minimize jet lag include:

- carbohydrate load 2-3 days prior to departure to increase fluid stores and prepare for upcoming event
- pre-order low-fat, high carbohydrate meals for the flight
- allow 1 day acclimatization/adjustment for every 1 to 3 time zones crossed
- consume 500 ml fluid within the hour before departure

- consume 250 ml fluid per hour of air travel; avoid dehydration from caffeinated and alcoholic beverages
- bring additional high carbohydrate, low-fat snack foods for the flight
- wear comfortable clothing to allow walking and stretching on flight
- if possible, try to sleep a little during the flight
- try to schedule the flight arrival as close to bed time as possible
- if arrival is in the morning, sleep for 1-2 hours then try to get out into the sunlight
- when arriving in the morning, consumption of high protein foods may stimulate the athlete, particularly since carbohydrates may elicit a relaxing and calming effect through serotonin release; however, if the athlete is soon to compete after arrival, then a high carbohydrate diet would be encouraged

Considerations for Road or Train Travel

Frequent rest stops, adequate fluids and portable high carbohydrate snacks may help the travelling athlete minimize adverse physical side-effects from road or train travel.

Food Safety

Prior to travel, identify suitable foods and beverages which may be available at the destination, particularly those available at the competition venue. The athlete may need to bring from home a supply of reliable snacks for training and/or competition. Athletes that are billeted in homes may want to provide meal and snack suggestions ahead of time to their hosts.

Diarrhea

Diarrhea is a common problem associated with travel, particularly due to microorganisms in the water supply. In foreign countries it may be necessary to avoid tap water, including ice cubes and when brushing their teeth. Vegetable salads should also be avoided since the vegetable ingredients would have been rinsed with tap water. A general rule of thumb regarding food safety in foreign countries is that “if you can’t boil it, cook it or peel it, don’t eat it!” Further preventive measures include eating in reliable restaurants, and avoiding meats and poultry that are not well cooked. Similarly, ensure that hot foods are served hot and cold foods are served at their desirable cold temperature.

Careful selection of food is the best way to avoid diarrhea related to travel. However, if the athlete does suffer from diarrhea, dehydration and electrolyte imbalances may occur. When managing diarrhea, caffeinated and alcoholic beverages should be avoided. Fruit and vegetable juices, sport drinks, tonic water and/or decaffeinated soft drinks may be consumed. Salty foods, such as soups, pretzels, and crackers may be appropriate. It may be necessary to temporarily avoid dairy products while the symptoms persist. Anti-diarrheal products may accelerate the athlete’s recovery, but attention must be given to whether a medication contains any banned or restricted substances. See Unit 3, section K for a comprehensive discussion on diarrhea. See Unit 16 - Medical Support for Teams Travelling - for further information.

E. Weight Control

Energy balance is achieved when food consumption (kilocalories) equals the amount of energy utilized by the body. A positive energy balance, leading to weight gain, occurs when food energy is consumed in excess of energy expenditure. Conversely, a negative energy balance, ie. weight loss, exists when energy expenditure exceeds food intake. Anthropometric measurements, ie. girth and fat fold measurements, are the most common techniques to assess body composition. Analysis is most useful

when the tests are repeated at two month intervals by the same qualified tester, thereby providing valuable information regarding the athlete's diet and/or training programme (see Unit 12 E Body Composition and Aanthropometry).

1. Weight Loss

If weight loss (body fat mass loss) is appropriate, it should be undertaken gradually, through sound nutritional practices. Athletes in a negative energy balance may compromise their lean body mass, strength, health and performance when attempting to achieve unrealistic low levels of body fat or weight. The use of rapid weight reduction methods, including fasting and dehydration, are to be discouraged. Weight loss attempts during intense training periods or competitive seasons may jeopardize performance and health, but if desirable, should be undertaken carefully.

Some very hard endurance training, such as for rowing, triathlon and running, requires an enormous daily energy replacement in order to stop progressive weight loss.

Table 13.11 Physiological effects of fasting and rapid weight loss.

Time	Physical Symptoms	Cause
0 - 2 days	Headache, nausea, dizziness, fatigue, hypotension	Loss of water (plasma volume)
24 hours	Start of protein catabolism	Hypocaloric intake and glycogen depletion
0 - onwards	Ketonuria Excretion of sodium and potassium	Fat catabolism Electrolyte imbalance
2 - 3 days	Depletion of glycogen	Gluconeogenesis
3 days - weeks	Uric acid production	Protein catabolism

Weight Loss Recommendations

- A gradual rate of weight loss (0.5-1.0 kg per week, or 1% of body weight) is encouraged through individualized intervention to modify the athlete's diet and training programme (if necessary).

- Create slight energy deficit (by reducing 500-1,000 kilocalories intake per day) calculated according to age, gender, height, weight, growth, and training demands.

- Provide minimum amount of carbohydrates to fuel training efforts (ie. 5 grams CHO per kg body weight per day).

- Limit dietary fat intake to 25% or less of total energy (reduce amount of added fats, use low-fat cooking techniques, be cautious of fast foods/snacks/restaurant meals, choose low-fat dairy products, lean meats, etc).

- Consume minimum amount of protein (1.2 grams protein per kg body weight per day).
- Eat small, frequent meals to maintain energy levels; adequate fluids are essential.
- Plan meals in advance; carry convenient snack foods for suitable choices.
- Eat meals slowly, chew foods thoroughly.
- Modify the training programme to increase energy expenditure as directed by the athlete's coach.
- During periods when the athlete is unable to maintain their usual training volume (ie. injury setback) they may need to adjust their energy intake to balance their reduced energy expenditure.

2. Weight Gain

In certain sports, such as weight lifting, the athlete may be required to maximize functional weight (lean body mass). These athletes are striving to build muscle mass rather than gain body fat mass. Weight gain can be as difficult as weight loss; rarely will an athlete gain more than 5 kg of muscle mass annually. Realistic weight gain goals must be considered. The following recommendations may help the athlete achieve gains in body weight:

- Increase energy intake by 500-1,000 kilocalories per day as determined by age, gender, height, weight, growth and training demands. A high carbohydrate diet (7 to 10 grams CHO per kg body weight per day) should be followed to fuel the anaerobic/strength training and spare protein oxidation. Allow a liberal intake of 30% of total energy as dietary fat.
- A customized, progressive resistance training programme should be implemented since this is the stimulus for growth and/or increasing strength. Sufficient dietary protein (1.4 to 1.8 grams protein per kg body weight per day) should be consumed to allow for anabolism.
- Allow sufficient rest and recovery between training sessions; adequate sleep is essential; curtail extra unnecessary energy expenditure.
- Consistent scheduling of 3 meals and 3 snacks each day may be necessary.
- Choose nutrient-dense foods; limit low-calorie "filling" foods (salads, soups, etc).
- Adequate fluids are essential, drink fluids in-between meals.
- Carry convenient snack foods for suitable choices.
- Consume a high energy drink daily (homemade or meal replacement commercial product).
- Avoid appetite suppressants, such as caffeine and nicotine.

Table 13.12 Snack suggestions for weight loss or weight gain.

Weight Loss	Weight Gain
low-fat milk, low-fat yogurt, low-fat cottage cheese tuna fish, hard boiled eggs raw vegetables fresh fruit dry crackers (Melba toast, bread sticks, soda crackers) rice cakes plain cereals popcorn	high-fat milk, high-fat yogurt, creamed cottage cheese, regular full-fat cheeses, ice cream, egg nog, nuts, trail mix, nut butters, legumes (dried peas and beans), dried fruits, fruit juices, avocado, cookies, granola bars, granola cereal, muffins, bagels, biscuits, pizza, homemade milkshakes, puddings, custards, commercial meal replacement products

3. "Making Weight" for Weight Class Sports

Athletes competing in weight category sports, such as wrestling, boxing, rowing and martial arts often have to lose weight prior to their competition to attain a specific weight standard. In order to attain peak performance at competitions, these athletes will need to plan their weight management strategies several weeks or months prior to their competition. Rapid weight loss attempts at the time of the event may jeopardize physical performance and health. Depending on sport regulations, the athlete may have to compete anywhere from 2 to 12 hours after weighing-in for the competition. Some re-feeding practices following the official weighing-in for competition may further jeopardize physical performance and health.

Physiological and Performance Problems Associated with Rapid Weight Loss

Unfortunately, athletes will often attempt rapid weight loss through forced dehydration combined with aerobic exercise while wearing air restricted clothing. As little as 1-2% loss of body weight from dehydration can decrease aerobic performance, and a loss of 3-4% of body weight through dehydration will negatively affect anaerobic capacity, anaerobic power, sweat rate, plus other physiological parameters. A 7-8% loss of body weight from forced dehydration can lead to extreme overheating. Although the athlete may be able to continue exercising under such conditions, their power output is considerably reduced and the athlete will not be conscious of his/her physical actions. Symptoms of vertigo, muscle spasms or respiratory problems can occur when the core body temperature exceeds 41 degrees Celsius. As well, the athlete's thermoregulation is no longer able to function properly, and the athlete will begin to shiver (as if feeling cold). If emergency treatment is not initiated the athlete can go into cardiac arrest. Rapid weight loss may also lead to glycogen depletion, hypoglycemia, electrolyte imbalance, protein catabolism, ketonuria, and gluconeogenesis.

Refer to section E. Weight Control - Weight Loss. As well, The American College of Sports Medicine has a position paper on this topic that can be accessed through http:// www.msse.org

Physiological and Performance Problems Associated with Rapid Re-Feeding and Rehydration

If the athlete has used sensible, healthy measures to achieve their competition weight, they will be able to follow the pre-event nutrition recommendations from section C - Competition Nutrition.

However, if the athlete has become moderately or severely dehydrated, they will need to gradually feed and rehydrate in a controlled manner. Consumption of excessive plain water can dilute and disrupt the electrolyte balance. As well, gastrointestinal discomfort and/or diarrhea may result from over-zealous food intake. Consumption of approximately 1 litre of fluid per hour along with 3 grams of carbohydrates per kg body weight per hour is a gradual approach to regain fluid and glycogen stores.

F. Eating Disorders

Athletes may be at greater risk for developing an eating disorder, compared to sedentary individuals. Within western populations, anorexia nervosa is estimated to affect <1% of females, and bulimia nervosa is thought to affect 2-3% of females. However, the prevalence of eating disorders amongst elite female athletes has been estimated to be as high as 18%. Approximately 32-62% of elite female athletes may suffer from the recently defined sub-clinical eating disorders - binge eating disorder, (ie. binging without purging), and disordered eating, (ie. excessive restricted food intake to lose or maintain body weight). Unit 7 - Issues Specific to Women, provides additional information about these disorders.

While both men and women can suffer from eating disorders, the ratio is approximately one man for every 10 women for bulimia and one man for every 20 women for anorexia nervosa; this may be an underestimate.

Coaches, parents and health professionals have an important role to play in the prevention, identification and treatment of eating disorders in athletes.

Sport-Related Factors Which May Trigger an Eating Disorder

To be an elite athlete necessitates a commitment to a high volume and intensity training programme. This constant physical and psychological stress may lead to the development of an eating disorder. It is important to emphasize that an eating disorder is a psychological problem, and not simply a problem with food itself, and can be caused by:

- striving for perfection - the achievement oriented, obsessive-compulsive, perfectionist nature of training and competition whereby an athlete rarely settles for a silver medal
- psychological stress - of training and competition
- the nature of the sport - participation in aesthetic, judgmental sports (eg. gymnastics, figure skating, diving, synchronized swimming), or it weight-limited events such as rowing (light weight and coxswains), and combative sports
- comments from others such as, judges, coaches, team managers, and parents regarding the athlete's weight and/or body composition
- body composition analysis - the athlete may misuse and misinterpret this information, especially if comparing their personal results to other athletes' results
- attributing poor performances - in training and/or competition, the athlete and/or coach may attribute poor performance(s) to the athlete's excessive body weight
- attributing good performances - in training and/or competition the athlete and/or coach may attribute good performance(s) to the athlete's abnormally low body weight
- physical maturation - the athlete may be uncomfortable with their body composition changes which occur during adolescence
- injury setback - as a result of an injury, the athlete may have to curtail their training volume; this situation may make it difficult for the athlete to adjust their food consumption patterns
- transition from sport to retirement - it may be difficult for the athlete to learn to adjust their food intake in relation to their change in exercise routine
- common precipitating factors - such as, family history of drug, alcohol or sexual abuse, parents divorcing, transitions during schooling, may also affect the athlete population

Diagnostic Criteria for Anorexia Nervosa

- refusal to maintain body weight over a minimal normal weight for age and height; weight loss leading to 15% below that expected, or failure to make an expected weight gain during periods of growth, leading to body weight 15% below that expected
- intense fear of weight gain or becoming over-fat, even though the athlete is underweight
- disturbance in the way in which the athlete's body weight, size or shape is experienced; the athlete claims to feel fat even when emaciated
- amenorrhea - the absence of at least three consecutive menstrual cycles not caused by pregnancy or a pathological condition

Diagnostic Criteria for Bulimia Nervosa

- recurrent episodes of binge eating (ie. rapid consumption of a large amount of food in a discrete period of time)
- a feeling of lack of control over eating behaviour during the eating binges
- the regular use of self-induced vomiting, laxatives, diuretics, strict dieting, fasting or vigorous exercise in order to prevent weight gain
- a minimum average of two binge eating episodes a week for at least 3 months
- persistent over-concern about body shape and weight

Signs and Symptoms, and Medical Complications of Anorexia Nervosa and Bulimia Nervosa

Clinical investigations to screen for the potential of an eating disorder should include assessment of the athlete's complete blood count, serum biochemistry, thyroid function, electrocardiogram and possibly bone density. Several of the medical signs and symptoms to diagnose an eating disorder may occur only after the condition has manifested for a lengthy period of time. Early warning symptoms of an eating disorder may include low self-esteem, depression, negative affectivity, body shape/ weight dissatisfaction, pre-occupation with dieting and food choice restrictions (eg. vegetarian, avoiding red meat, severe dietary fat restrictions).

Nutritional and Physical Performance Characteristics of Athletes Suffering From an Eating Disorder

In addition to the medical assessment, a thorough diet history may identify self-imposed nutritional characteristics common amongst eating disorder sufferers, such as:

- energy intake deficit, in relation to estimated energy expenditure
- dietary fat restriction
- vegetarian (lacto-ovo, vegan); avoids red meat and/or poultry
- excessive dietary fibre intake
- possible restriction of milk products
- avoidance of "empty calorie" foods, eg. desserts, candy, etc
- excessive consumption of "diet" foods
- potential deficiency in dietary protein, fat, iron, zinc, calcium and carbohydrate
- body weight fluctuations
- poor exercise recovery related to training and competition
- inconsistent physical performances in training and competition
- excessive training beyond the training programme

Nutritional Management of Eating Disorders

The goals of nutritional management for treatment of eating disorders include: 1) to normalize eating habits 2) to prevent bone loss 3) to re-establish normal menses 4) to overcome the eating disorder.

To re-establish normal menses it may be necessary for the amenorrheic athlete to achieve a body weight which is 2-3% above her last menstrual weight. With particular reference to the amenorrheic athlete, the nutritional management would include:

- increase energy intake by at least 350-500 kcal per day through adequate dietary protein, fat and CHO
- may need to reduce energy expenditure by 10-20% (ie. eliminate one training session per week)
- 1,000-1,500 mg calcium with 400 I.U. vitamin D
- restrict “diet” foods and “filler” foods (eg. soups, salads, excess water, etc)
- gradually re-introduce foods that the athlete restricts and foods which may trigger a binge

Confronting the Athlete Suspected to Have an Eating Disorder

Based on the screening procedure, if an eating disorder is suspected, the athlete should be confronted in privacy. Although the athlete may deny that a problem exists they should be followed closely. It may be prudent to avoid discussing the athlete’s weight change(s) that may have occurred, and instead focus on performance outcomes (eg. sub-optimal performance, reduced strength, poor recovery) and other starvation-related symptoms (eg. mood swings, social withdrawal, poor concentration and memory).

The treatment for eating disorders should be multi-disciplinary to include psychological, nutritional and physical intervention. It would be beneficial if the multi-disciplinary team members are familiar with sport, in terms of training and competition demands. It may be necessary that the athlete’s family member(s) and/or coach attend the treatment sessions.

G. Vegetarianism

Vegetarian diets are based on the consumption of plant foods with varying degrees of restriction on the type of animal products included. If well planned and nutritionally balanced, a vegetarian diet may provide adequate nutrients (especially high fibre, high carbohydrate and low fat) necessary for an active lifestyle. However, the more foods that are restricted, the greater the challenge to obtain adequate nutrition.

Types of Vegetarian Diets - in terms of animal product restrictions:

- Vegan : only eats food plant sources; does not consume any animal foods
- Lacto-Vegetarian: eats dairy products while avoids all other animal products
- Lacto-Ovo Vegetarian: eats eggs and dairy products; does not consume meat, fish, poultry and possibly gelatin and rennet
- Semi-Vegetarian: usually avoids meat but eats poultry, fish, eggs, and dairy

Nutrients that are often reported to be of concern for vegetarians include:

- inadequate protein (usually of low quality, incomplete sources of essential amino acids) and inadequate energy intake
- low intake of total iron and poor bioavailability of the iron that is consumed (ie. non-haeme)

- inadequate dietary consumption of zinc, vitamins B6, D, B12 and riboflavin
- poor intake of calcium

Vegetarian diets must be well planned to ensure that the athlete is receiving the full range of essential nutrients. In part, they will need to choose a variety of whole grains, including enriched cereals, legumes, particularly calcium, fortified soy based beverages and tofu. The following table indicates the combinations of plant incomplete protein sources that complement to provide adequate complete protein.

Table13.13 Plant and plant combinations.

Plant and Plant Combinations	Examples
Legumes and Cereals some legumes include dried beans, dried peas, lentils, soy beans some cereals include rice, wheat, corn	bean and cornmeal tortillas baked beans & whole wheat or corn bread pea or lentil soup with bread beans and rice casserole lentils and pasta tofu and rice hummus & whole wheat pita bread
Nuts and Cereals	peanut butter and whole wheat bread nut butter and bread
Legumes and Seeds	hummus and tahini paste soyanut seed and mixed seed snack
Leafy Green Vegetables and Seeds	bok choy and seasame seeds broccoli and sunflower seeds

Table 13.14 Plant and animal combinations.

Plant and Animal Combinations	Examples
Legumes and Cheese, Eggs, or Milk	beans and cheese beans and eggs
Cereals and Milk, Cheese, or Eggs	granola and milk pasta and cheese oatmeal and milk toast and eggs rice pudding
Leafy Green Vegetables, Cheese, or Eggs	broccoli and cheese sauce spinach souffle vegetarian pizza

H. The Diabetic Athlete

The type and duration of exercise recommended depends on the presence of physical complications and the degree of metabolic control. For those with uncomplicated diabetes, physical activity does not need to be restricted, but attention should be given to the prevention of hypoglycemia during and after exercise. Diabetics with vascular complications may need to restrict high intensity anaerobic activities that drastically elevate the blood pressure.

Practical guidelines for Insulin Dependent and Non-insulin Dependent Diabetics

- Regular exercise may help to establish optimal blood sugar control especially when exercising consistently at the same time of day.
- Diabetics should exercise with someone else who is aware of hypoglycemia symptoms; emergency foods should be readily available during exercise.
- Insulin should not be injected into the primary muscles used during exercise as this may mobilize the insulin faster and possibly lead to hypoglycemia.
- It is best not to alter the insulin dose for exercise; instead eat more food as necessary.
- Test blood glucose before and after exercise; do not exercise if hyperglycemic because of the danger of ketosis.
- Carbohydrate loading is not recommended for diabetics.
- Always exercise after eating a snack or meal; consume readily absorbed carbohydrate (eg. fruit juice, fruit) before high intensity exercise; choose complex carbohydrates with small amounts of protein (eg. peanut butter on toast) prior to low intensity exercise.
- Ingest carbohydrate during and immediately after exercise while continuing to monitor blood glucose levels for several hours after activity; extra food intake after activity may delay post-exercise hypoglycemia.
- Consume fluids before, during and after exercise.
- Through consultation with a physician, insulin dosage may need to be adjusted in relation to the intensity and duration of the physical activity.

I. Dietary Trouble Shooting

The athlete may present with a variety of symptoms regarding their changes in body composition, motivation and energy level, physical performance in sport and other physiological concerns. In some cases, the etiology may be related to the athlete's nutrition. The following table identifies classic physical symptoms which may detract from achieving optimal performance, along with some nutrition suggestions to possibly remedy the concerns. This summary does not represent plausible medical intervention which may resolve the symptoms presented.

Table 13.15a Dietary trouble shooting.

Symptom	Possible Nutrition-Related Cause	Nutrition Recommendation(s)
"Empty" muscle sensation, poor endurance, lacking speed to accelerate	Depleted glycogen reserves; Overtrained; Inadequate rest	Increase dietary carbohydrate to 7-10 grams per kg body weight per day; Ensure optimal nutrition for recovery after exercise
Lethargic, no motivation, mood swings, irritable	Hypoglycemia; Depleted glycogen reserves; Failed to consume adequate nutrition during exercise	Consider pre-event snack; Consider nutrition protocol during exercise
Headache, rapid pulse, low energy	Dehydration; Hypoglycemia; Failed to consume adequate nutrition during exercise	Rehydrate; Consider nutrition protocol during exercise (fluids and carbohyrate) - use sport drink
Muscle cramps	Dehydration; Inadequate dietary calcium or sodium	Rehydrate; Ensure to consume optimal fluids during exercise; Consider calcium and sodium intake
Weight loss - mostly loss of muscle	Inadequate energy intake, especially insufficent carbohydrate; Excessive training with inadequate rest	Increase carbohydrate intake to 7-10 grams per kg body weight per day; Ensure minimum dietary protein comsumption meets sport demands; May consider high energy drink/meal replacement added to diet
Inconsistent performances; Poor recovery	Have not established consistent nutrition regime	Consideration of training diet, with emphasis on recovery nutrition
No appetite before competition	Pre-event nervousness	Consume at least 3 grams carbohyrate per kg body with 2-3 hours pre-event in the form of a liquid or solid foods

Table 13.15b Dietary trouble shooting continued.

Symptom	Possible Nutrition-Related Cause	Nutrition Recommendation(s)
During exercise abdominal cramps with possible diarrhea	Ate too soon before exercise; Too much fruit juice during exercise; Sport drink may have been too strong	Consider meal timing/meal composition pre-event; Avoid fruit juice during exercise; Dilute sport drink to 5-7 % carbohydrate solution
Frequent illness (eg. URTI)	Inadequate energy intake; Inadequate carbohyrate and/or protein intake; Diet lacks essential vitamins and minerals; Inadequate rest	Ensure adequate energy intake; Consider carbohyrate, epecially during exercise; Consider protein intake; Assess diet for adequacy of vitamins and minerals
Poor appetite after training or competition	High intensity exercise has reduced appetite	Consider nutrition for recovery, possibly in liquid form
Weight gain	Too much dietary fat; Eating when bored; Bulimia	Reduced added fats; Choose leaner proteins and low-fat dairy products; Limit fast foods and high fat snacks; Consider psychological appetite triggers; Seek professional support re:bulimia
Tired, heavy muscles	Lactic acid produced from oxidizing carbohydrates for physical energy	Rehydrate after exercise; Use sport drink during exercise; Consider nutrition for recovery
Ammenorrhea or oligomenorrhea	Inadequate energy intake; Inadequate dietary protein; Excessive high fibre diet	Add 350-500 kcal per day with adequate dietary protein; Include calcium supplement if <1,000 mg per day from diet
Constantly hungry	Diet too low in fat; Inadequate energy intake	Slightly increase dietary fat, Ensure adequate dietary protein and total energy

Evaluation of Nutritional Products

The increased interest in physical fitness and sport performance has led to a proliferation of sport nutrition product sales. The following guidelines provide insight into evaluation of the efficacy of nutritional products (pills, powders, bars and beverages) available to athletes in the marketplace.

- As a general rule, athletic performance is not enhanced by the vast array of special nutritional ergogenic aids and supplements. The short-cut approach through supplementation to sport performance should be discouraged; good eating habits are the foundation to optimal nutrition and physical well-being.

- Read the information label of any nutritional products under consideration. Many products are NOT regulated or controlled, especially herbal products; products may contain other chemicals, including contaminants or prohibited substances.

- Does the product(s) supply excessive amounts of one or more nutrients? Ingesting excessive quantities of vitamins and minerals may cause side effects that will impair health and fitness.

- Does the product contain substances that could cause a positive doping control result?

- Does the product have a written guarantee that it contains NO prohibited substances? Plants and herbs contain thousands of different kinds of chemicals, including many drugs that will lead to a positive doping test. Be aware that some ingredient lists are NOT complete. Rare or unusual ingredients are often difficult to examine. The athlete is ultimately responsible for ensuring that any product they take does not contain a prohibited substance.

- Assess the relative cost of the product per week or month. Is it more affordable to purchase food?

- Assess the product usefulness and accuracy of the information provided. Are the claims realistic or do they suggest unrealistic outcomes? Are the claims based on science or testimonials? (ie. comments from other users)

- If convinced that the product is based on scientific theory and testing, then suggest that the athlete tries it in training! NEVER change dietary routines prior to competition.

J. Case Presentations

1. Weight Loss

Case History - Weight Loss

A 17-year-old competitive female swimmer desires to lose 5 kg body weight. The athlete is training 20-24 hours per week, and has been a competitive swimmer for 8 years. Her recent body composition analysis, using anthropometric measurements, reveals 18% body fat (an increase of 2% over 4 months duration). Her body weight is 70.3 kg (155 lb.), height is 173 cm (5'8"), her goal weight is 65 kg (145 lb.) at 14-16% body fat.

The swimmer's diet history recorded over 3 days indicates regular consumption of 2,500 - 2,800 kcal per day spread over 3 meals and 3 snacks. Several sources of dietary fat are apparent in her diet, including potato chips, peanut butter, pizza, desserts and muffins. She has difficulty sensing satiety and is often ravenous after swim training.

Discussion

The goal of this swimmer's nutritional care plan is to lose body weight and body fat while maintaining lean body mass and have good energy to continue to train. The nutritional plan considered the athlete's meal timing, meal/snack composition (especially fat intake), training demands and appetite triggers. At the time of attempting to lose weight, the athlete is in the general preparatory phase of her training programme, her major competitions commence in 2.5 months time.

Using the Harris Benedict Equation, this athlete's Basal Energy Expenditure is approximately 1,600 kcal per day. She requires approximately 2,400 kcal for weight maintenance and thus approximately 1,900 kcal per day for 0.5 kg weight loss per week. The nutritional plan of 1,900 kcal, dispersed over 3 meals and 3 snacks, contains 300 grams carbohydrate (4.5 grams per kg body weight - using goal weight), 79 grams protein (1.2 grams per kg body weight - using goal weight), and 25% total energy from fat (43 grams fat per day).

A portion of the carbohydrate in the care plan is used as a sport drink during training to dampen the post-exercise hunger prior to the recovery meal. The athlete is educated regarding low-fat food choices at meals and snacks. Upon discussion with the athlete's coach, 2 additional dry-land training sessions (cycling/ jogging) are added to the athlete's training programme.

2. Eating Disorder

Case History - Eating Disorder

A 19-year-old competitive female rower has been struggling with bulimic/anorexic episodes for 2 years. However, she has had a body image problem since 14 years of age. Her greatest frequency of binge/purge cycles has been 5 occurrences per week. This athlete trains 27-30 hours per week.

Her onset of menses occurred at 16 years of age. She has been amenorrheic for 2.5 years. Her bone density is normal. After taking oral contraceptives, her menses resumed. During the past 2 years, this rower dropped to10% body fat during the competitive seasons and increased to 16% body fat during non-competitive phases. Her most recent body composition analysis reveals a loss of 3 kg body fat and 2 kg lean body mass over a 4 month period.

The athlete's blood analysis indicates early stages of iron deficiency (elevated TIBC, decrease RBC, decrease transferrin saturation, with normal haemoglobin, haematocrit, serum iron and ferritin levels). Her total protein and serum albumin are normal, while her cortisol level is elevated.

At 63 kg (139 lbs) body weight, the rower's diet history indicates 1,200 kcal consumption per day (when restrictive eating) dispersed over 4 small snacks and 2 meals daily. More specifically, her consumption consisted of 3 grams carbohydrate per kg body weight per day, 1.0 gram protein per kg per day with 16% total energy from dietary fat.

She is experiencing several starvation-related symptoms, including exhaustion and excess lactate levels during training. Her performances are inconsistent in competition. She denies hunger, is pre-occupied with thoughts regarding food, and is pleased with her current body composition. This rower continues to meet with a sport psychologist who specializes in eating disorders.

Discussion

The goal of the rower's nutritional care plan is to help overcome the eating disorder (and amenorrhea) through gradual normalization of her eating patterns. Lengthy discussion regarding short and long term effects of under-eating related to physical performance and health are presented. The athlete's nutritional management is discussed with her physician, psychologist and coach. Her parents are not involved with the treatment.

Her nutritional plan includes a gradual increase up to 5-7 grams carbohydrate per kg current body weight per day, with 1.4 grams protein per kg per day, 25% of total energy from dietary fat (sources of fat at each meal), 1,200-1,500 mg calcium per day (through food and supplementation), along with regular selection of iron-rich foods.

She is presented with suggestions to cope with normalized eating, including the gradual incorporation of foods that may trigger a binge.

3. Poor Endurance

Case History - Poor Endurance

A 24-year-old competitive male road cyclist has difficulty sustaining his endurance throughout cycling stage races (a series of road cycling races held over successive days). After the third event within a stage race, this cyclist will often lose his appetite. Although his body weight (67.5 kg/150 lb) was appropriate for his height (174 cm/5'8.5") he will often experience a loss of 5% of body weight during stage races.

His blood analysis is normal for his iron status, electrolytes and other parameters.

The diet history during training indicates consumption of 3,000-3,400 kcal per day based on 57% carbohydrate, 14% protein and 29% fat, including 2.8 litres of fluid per day. However, during a 4 hour stage race his average energy intake only increases by 500-700 kcal, along with additional consumption of 1.75 litres of fluid.

Discussion

While this cyclist is able to maintain his energy balance for training, he fails to adjust appropriately to the energy expenditure during his races. Therefore, to enhance this athlete's endurance, his nutritional care plan includes carbohydrate loading prior to stage races, nutrition protocol during races and training, as well as recovery nutrition after races and training.

The cyclist is encouraged to carbohydrate load (supersaturate glycogen stores) the 3 days prior to a stage race. To achieve intake of 3,000- 4,000 kcal per day, he will consume 7-10 grams of carbohydrate per kg body weight per day (473-675 grams carbohydrate per day), 1.2-1.6 grams of protein per kg per day (81-108 grams protein per day), approximately 25-30% total energy from dietary fat, and 3.5-4 litres of fluid per day.

During training sessions and races the athlete is to follow a regular schedule of food and fluid intake at a rate of 60 grams of carbohydrate per hour of cycling along with 600-900 ml of fluid per hour of cycling (containing 0.5-1.0 gram sodium per litre and 0.2 gram potassium per litre). The cyclist consumes these foods as sport drinks, sport bars and gels. It is imperative that the athlete practice consistency with nutrition during training and races to establish a routine and optimize endurance.

Following training rides and races the cyclist's recovery nutrition is to include at least 2 grams of carbohydrate per kg and 0.5-1.0 gram of protein per kg consumed immediately after activity. His fluid volume for rehydration is dependent on his pre and post-exercise body weight. Because of lack of appetite after racing, the cyclist is encouraged to consume appropriate drink formulations purchased commercially or homemade.

K. References

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For further information, refer to the following web sites:

http://www.msse.org/
http://ESPN.go.com/trainingroom/s/nutrition/archive.html
http://science.holycross.edu/departments/biology/kprestwi/exphys/exphys_nutrition.html
http://www.sfu.ca/~jfremont/exercisephysiology.html