NUTRITIONAL CONSIDERATIONS IN THE ATHLETE

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Why are we discussing this?

- Athletes need to consume adequate energy during periods of high-intensity and/or long-duration training to maintain body weight and health, and maximize training effects
- Athletes do not need a diet substantially different from that recommended in the Dietary Guidelines for Americans and Eating Well with Canada's Food Guide

Disclosures

- I have no financial relationships with the grantor or any commercial interests that would have direct impact on the content of the program.
- I will not be discussing experimental or unapproved use of devices
- I prepared most of this talk sitting in cafés eating bagels and pastries using time that I should have been in the gym

Consequences of Poor Nutrition

- Increased risk of fatigue, injury, and illness
- Loss of muscle mass
- Menstrual dysfunction
- Loss of, or failure to gain, bone density
- Prolonged recovery
- Potential long-term consequences
  - Osteopenia

Key Nutrition and Performance Goals

- Achieve and maintain ideal body mass
- Optimize and maintain hydration
- Maximize performance
- Promote recovery
- Individualization
- Minimize long term consequences

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Energy Metabolism

- Energy expenditure must equal energy intake to achieve energy balance
- Calories Taken In = Resting Metabolic Rate + Thermic Effect of Food + Physical Activity

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Physiology of Exercise (Briefly!)

- Adenosine triphosphate
  - Main fuel for the body's functions
  - Formed from the storage form of macronutrients
    - Carbohydrates (glucose and glycogen)
    - Proteins (amino acids)
    - Fats (fatty acids from adipose tissue and intramuscular triglyceride)
  - Cells store a limited quantity and it must be replenished
- Creatine phosphate
  - Another storage form of energy
    - ATP reserve in muscle

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Three Energy Systems

- Immediate system
  - ATP/phosphocreatine system: fuels high-intensity or high-power bursts of activity lasting 5 to 6 seconds.
  - Utilizes ATP and creatine within the muscle
- Short-term system
  - Anaerobic glycolytic system: uses muscle glycogen and glucose that are metabolized through the glycolytic cascade.
  - Supports events lasting 60–180 seconds.
- Long-term system
  - Aerobic system: takes place in the mitochondria of cells and may use carbohydrate, fat, or protein as substrate for ATP in the presence of oxygen
  - Supports events lasting longer than 2-3 minutes

Role of Glycogen

- Carbohydrates and fats are the two main sources of energy for athletic activity
  - As these are depleted the body will start to utilize proteins
- Carbohydrates are converted to glycogen and stored in muscles and liver.
- Glycogen
  - Primary fuel source for endurance events of moderate to high intensity
  - Repletion is slow and recovery time is directly related to ability to replenish
- Maintaining and restoring glycogen is key to performance

Creatine Supplementation

- Creatine phosphate is an ATP reserve in muscles
  - Approximately 4x more creatine than ATP stored in the muscle
- Mechanism
  - Creatine is synthesized in the liver and stored in the muscles
  - Hydrolysis of creatine phosphate results in rapid production of ATP
    - Creatine depletion is the limiting factor in anaerobic exercise
    - By replenishing muscle stores, you gain shorter recovery and increased training load
- Efficacy
  - Supplementation has a small, but real, beneficial effect on anaerobic activity, specifically short-duration, repetitive, high-intensity exercise
    - Responders and non-responders
  - No recommendations for use in athletes under 18 years old

Three Energy Systems

- Energy systems used during exercise for muscular work include:
  - Anaerobic
    - ATP/phosphocreatine
    - Glycolytic
  - Aerobic
    - Oxidative pathways
- No form of exercise is exclusive to one system

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Adaptations in Athletes

- Training does not alter the total amount of energy expended but rather the proportion of energy derived from carbohydrates and fat
- Endurance training increases the muscles' capacity to oxidize fat as a fuel source
  - Muscle glycogen and protein are spared.

Adaptations in Athletes

- At higher exercise intensities, the body is unable to oxidize fat as a fuel source; thus, the availability of muscle glycogen stores is crucial to exercise performance.
- Protein turnover may become more efficient in response to endurance exercise training
- A trained individual will utilize a higher percentage of fat than an untrained person at the same work load

Carbohydrates

- Carbohydrate recommendations for athletes range from 6 to 10 $g \cdot kg^{-1}$ body $weight \cdot d^{-1}$
  - amount required depends on the athlete's total daily energy expenditure, type of sport, sex, and environmental conditions
- Recommended 45-65% of daily energy intake
  - Estimate that 2/3 of a plate should be carbohydrate-rich foods
    - General training: 5-7 g/kg
    - Endurance athletes: 7-10 g/kg
    - Ultra-endurance: >11 g/kg
- Carbohydrate consumption at a rate of ~30-60 $g \cdot h^{-1}$ has been demonstrated to maintain blood glucose levels and sustain exercise performance

Energy Requirements

- Highly variable and based on age, gender, body size, exercise type and frequency, etc.
- Male athletes: 4000-6000 kcal per day
- Female athletes: 1600-3000 kcal per day
- Female Olympic Gymnasts
  - 1900 kcal/day
- Tour de France Cyclists
  - 7,000+ kcal/day
- College Football Players
  - 7,500-8,500 kcal/day

What does 50 grams of carbohydrate look like?

- Foods supplying 50 grams carbohydrate
  - 500 ml fruit juice
  - 3 medium pieces of fruit
  - 1 honey sandwich
  - 2 breakfast bars
  - 1 sports bar (check label)
  - 1.3 bagels
  - 1/2 cup dried fruit
  - 1 cup white rice
  - 1 baked potato

Carbohydrates

- Carbohydrates (4 kcal/g)
  - Preferred energy source for working muscles
  - Predominant fuel for exercise performed at an intensity of 65% of maximal oxygen consumption (VO_{2max}) or more
    - Range at which most athletes train

Sports Bars

- Easily accessible source of carbohydrate
- Select a bar with 25-40 grams of carbohydrate and fewer than 15 grams of protein
  - Average sports bar provides about 40-60 grams of carbohydrate.
    - Consume one bar per hour
- Many bars provide complex proteins and may be high in fat, which slows digestion.
  - Vary in type and amount of carbohydrate, protein and fat.
  - Some provide only 150 kcal and others up to 340 kcal
  - Many contain other agents, herbs, etc.

Sports Drinks

- Excellent choice because they are a mix of carbohydrates, water and occasionally electrolytes
- Most offer a blend of carbohydrate sources at 4-8% solution
  - Greatest rates of carbohydrate delivery are achieved with a mixture of sugars (e.g., glucose, sucrose, fructose, maltodextrin)
- The carbohydrate concentration should not be >8% as highly concentrated carbohydrate beverages reduce gastric emptying

Composition of Carbohydrate Gels

Crank Sports e-Gel	82% Complex/ 18% Simple CHO	Amino acids, vitamin B6, antioxidants
GU Energy Gel	80% Maltodextrin/ 20% Fructose	Amino acids, herbal blend, antioxidants, caffeine
Power Gel	Maltodextrin, Fructose, Dextrose	Amino acids, vitamins C/E, caffeine, kola nut, ginseng
Clif Shot Energy Gel	60% Complex/40% Simple CHO from rice	Magnesium, caffeine (some flavors)
Hammer Gel	100% Maltodextrin	Caffeine (some flavors), amino acids

Sports Drinks

- Carbohydrate consumption can be beneficial to sustain exercise intensity during events lasting over 60 minutes
- Considering our goal of ~30–60 g·h^{-1}
  - An individual could ingest 0.5-1 liter of a conventional sports drink each hour (assuming 6–8% carbohydrate, which would provide 30–80 g·h^{-1} of carbohydrate) along with sufficient water to avoid excessive dehydration.
- Fitness waters do not provide enough carbohydrate to boost endurance, but they can keep the athlete hydrated.

Cutting Edge Sports Nutrition

- Fruit
  - Easily digested
  - If dried, easily transported
- Most fruits provide about 15 grams of carbohydrate per serving.
  - A serving of dried fruit equals about 1/4 cup, or the equivalent, of fresh fruit (two nectarine halves or four dried plums).
- Goal: 1-2 servings before a workout and 2-3 fruit servings for every hour of activity

Carbohydrate Gels

- Designed to deliver large amount of carbohydrate in compact form
- Very slowly absorbed by the body and must have adequate amounts of water to dilute and lower osmolality
  - 4-8 ounces of water per packet
- Effective source of energy, but challenge is taking in enough fluid.
- About 25 grams carbohydrate per package
  - 1-3 packets per hour
- Check the label
  - May contain ginseng and other herbs, amino acids, vitamins, and co-enzyme Q10, which are not supported by research
  - Many also contain caffeine

Proteins

- Proteins (4 kcal/g)
  - If carbohydrate intake adequate, amino acids should provide less than 5% of total daily energy expenditure.
- Unlike carbohydrates, there is no protein reservoir
  - Poor carbohydrate replacement may cause an increased use of proteins.
    - This deficit may effect tissue repair and act as a component of metabolic, transport, and hormonal systems

Protein Requirements

- Protein recommendations for endurance and strength trained athletes range from 1.2 to 1.7 g·kg^{-1} body weight·d^{-1}
- Daily requirements higher than sedentary counterparts
  - Estimated 1/3 of plate should be protein-rich foods
    - Endurance athletes: 1.2-1.3 g/kg
    - Strength athletes: 1.6-1.7 g/kg
    - Vegetarian athletes: 1.3-1.7 g/kg
  - No benefit beyond 2g/kg
- Protein or amino acids consumed after strength and endurance exercise can enhance maintenance of, and net gains in, skeletal muscle

Vitamins and Minerals

- Assist with synthesis and repair of muscle tissue during recovery from exercise and injury
- Routine exercise may also increase the turnover and loss of these micronutrients from the body
  - Calcium and vitamin D, the B vitamins, iron, zinc, magnesium, as well as antioxidants (vitamins C and E, A-carotene, and selenium)
- Athletes at greatest risk for poor micronutrient status are those who:
  - Restrict energy intake or have severe weight-loss practices
  - Eliminate one or more of the food groups from their diet
  - Consume unbalanced or low micronutrient-dense diets
- A daily multivitamin-and-mineral supplement is not necessary if adequate nutrition is maintained through a balanced diet

Protein Intake/Supplementation

- Positive protein/amino acid balance is important in muscle recovery
  - These recommended protein intakes can generally be met through diet alone, without the use of protein or amino acid supplements.
- No current evidence that athletes need to supplement a healthy balanced diet with protein powders or amino acid supplements.
- However…a protein-containing snack (i.e. protein shake) may be a more convenient way to meet post-exercise protein requirements

Pre-exercise Meal

- A single pre-event meal will not compensate for a poor training diet
- Timing of meal prior to exercise
  - If small (400-500 calories), 2-3 hours pre-exercise
  - If large or high quantity protein or fat, 5-6 hours pre-exercise
- Carbonated drinks should be avoided as they may cause stomach discomfort
- Caffeine?
  - Balance ergogenic effect with nausea, anxiousness, and diuretic effect

Fat Requirements

- Fat (9 kcal/g) provides the body's largest store of potential energy.
- General guidelines suggest fat intake of 20-35% of daily calories
  - Calculate protein and carbohydrate relative to body weight, the remainder of the caloric intake should come from fat
    - 1.0 to 1.2 g/kg
- After depletion of muscle glycogen, the body will shift towards oxidation of fatty acids. This is trainable.
  - Aerobic training enhances the body's ability to utilize fatty acids
- Very low fat diets (<15%) detrimental to performance and health
  - May lead to deficits in energy, fat-soluble vitamins, and essential fatty acids.

Pre-exercise Meal

- Definite focus on carbohydrate intake to maximize maintenance of blood glucose
  - 200 to 300g of carbohydrate consumed 3-4 hours before exercise has been shown to enhance performance.
  - Carbohydrates which are high in fiber or gas-forming (bran products, legumes, and certain vegetables, such as onion, cabbage and cauliflower) are not recommended as they may cause intestinal discomfort
- Should also be
  - Moderate in protein
  - Low in fat to facilitate gastric emptying and minimize gastrointestinal distress
  - Composed of familiar foods and be well tolerated by the athlete
- Equivocal data regarding glycemic index and performance

During Exercise

- Primary goals are to replace fluid losses and provide carbohydrates for maintenance of blood glucose levels.
  - Consuming carbohydrates (approximately 30–60 $g \cdot hr^{-1}$) has been shown unequivocally to extend endurance performance
- Important for events lasting longer than an hour or when exercising in an extreme environment
- Small amounts spaced out are better
  - Consuming a bolus of carbohydrate after 2 hours of exercise is not as effective as consuming the same amount at 15- to 20-minutes intervals throughout the 2 hours of activity
- Primarily glucose should be consumed
  - Fructose alone is not as effective and may cause diarrhea
  - Mixtures of glucose and fructose, other simple sugars and maltodextrins, seem effective

Dehydration

- Results in
  - Increased core temperature
  - Increased heart rate
  - Increased perceived exertion
- Risk factor for cramping, heat exhaustion, exertional heat stroke, rhabdomyolysis
- Increases physiologic strain and perceived effort to perform the same exercise task
  - Accentuated in hot weather

After Exercise

- Goals are to provide adequate fluids, electrolytes, and carbohydrates to replace muscle glycogen and ensure rapid recovery
- Carbohydrate intake of approximately 1.0–1.5 $g \cdot kg^{-1}$ body weight during the first 30 min and again every 2 hours for 4–6 hours will be adequate to replace glycogen stores.
  - Less important if there are one or more days between training sessions
- Protein consumed after exercise will provide amino acids for building and repair of muscle tissue.
  - 4:1 carbohydrate-to-protein replacement after exercise probably helpful

Dehydration

- Fluid loss may be significant
  - up to 4 L/hour
- Many individual factors play a role in rate of fluid loss
  - Body weight, genetic predisposition, heat acclimatization, metabolic efficiency, cardiovascular fitness, sport, climate, etc.
  - American football players may lose 9L/day where cross country runners may lose 3.5L/day in similar environment and over similar time

Hydration Strategies

- Fluid balance necessary for:
  - Cardiovascular functioning
    - Maintain plasma volume
  - Thermoregulation
  - Injury prevention
  - Optimal performance
  - Recovery from exercise
- A good goal is to prevent >2% body weight loss due to water deficit

Hydration Strategies

- Thirst is not an adequate indicator
  - Already 1-2% dehydrated
- Check for signs of dehydration
  - Infrequent urination, dark yellow urine, headache, and weakness should be clear signs and symptoms of dehydration
- Comparison of pre- and post-exercise weight

Establishing Fluid Needs

- Daily water balance depends on the net difference between water gain and water loss
- For well-hydrated persons, who are in energy balance, a first morning (after urinating) nude body weight should be stable and fluctuate by <1%
  - Use three consecutive measurements to establish a baseline
    - May require more measurements in women
  - Body weight changes can reflect sweat losses during exercise and can be used to calculate individual fluid replacement needs for specific exercise and environmental conditions
- Fluid consumption that exceeds sweating rate is the primary factor for exercise-associated hyponatremia
  - Your patient should NEVER weigh more after an event

Fluid Replacement During Exercise

- Amount and rate of fluid replacement depends upon the individual sweating rate, exercise duration and opportunity to drink
  - Drink 3-8 fluid ounces of a sports beverage every 15-20 minutes
- For exercise <60 minutes, hydration with water is sufficient
- For exercise >60 minutes, beverages containing electrolytes and carbohydrates (6-8%) can help sustain fluid and electrolyte balance and improve exercise performance

Example of Fluid Needs

- To estimate sweat rate in a specified period of time during defined workload
  - A: Body weight: Pre - Post
  - B: Fluid intake: Total volume
  - C: Urine volume
- Sweat loss = A + B - C
- Sweat rate = Sweat loss/time
- Body weight
  - Before = 70 kg and after = 67 kg
- Fluid intake = 1.8 L
- Urine volume = 0.7 L
- Time = 2 hours or 120 min.
- Sweat loss = (3 + 1.8 - 0.7) = 4.1
- Sweat rate = 4.1 L/2 hrs = 2.05 L/hr

Fluid Replacement Post-exercise

- Most athletes complete an event dehydrated to some extent
- Given time, normal meal and fluid intake will replete losses
- Athletes on a tight training schedule or planning additional activities should attempt more aggressive rehydration strategies
  - Amount based on pre- and post-exercise body weight
  - Consume 16-24 ounces of fluid for each pound (0.5 kg) of body weight lost

Fluid Intake Pre-exercise

- At least 4 hours before exercise, drink approximately 5–7 mL·kg^{-1} body weight of water or a sport beverage
  - Drink 16-20 fluid ounces of water or sports beverage at least four hours before exercise.
  - Drink 8-12 fluid ounces of water 10-15 minutes before exercise.
- Some athletes engage in hyperhydration with fluids that expand the extra- and intracellular spaces (e.g., water and glycerol solutions)
  - Increases the risk of having to void during competition
  - Provides no clear physiologic or performance advantage over euhydration
    - Controversial

Pitfalls and Consequences

- Hypohydration
  - Practice used in weight class sports
    - wrestling, boxing, lightweight crew, martial arts, etc.
- Hyponatremia (Serum sodium < 130 mmol·L)
  - Results from prolonged, heavy exercise with failure to replace sodium, or excessive water intake.
  - More likely in novice marathoners who are not lean, who run slowly, or who consume excess water before, during, or after an event
- Muscle cramping
  - Associated with dehydration, electrolyte deficits, and muscle fatigue
  - More common in profuse sweaters or “salty sweaters”

Vegetarian Athletes

- Well-planned vegetarian diets can provide sufficient energy and an appropriate range of the macronutrients to support performance and health.
- Vegetarian athletes can meet protein needs from plant sources with both plant and animal protein sources appearing to provide equivalent support for athletic performance.
  - Should consume at the higher end of current recommendation ranges because of the lower digestibility and essential amino acid profile of plant protein.
- Consuming enough calories may be challenging
  - Generally increased bulk but decreased calories

Recommended Reading

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Vegetarian Athletes

- Female vegetarians are particularly at risk for non-anemic iron deficiency, given the lower bioavailability of iron from plant foods.
- Vegetarian athletes may be at risk for low intake of
  - Protein
  - Fat
  - Key micronutrients such as iron, calcium, vitamin D, riboflavin, zinc, and vitamin B12.

Female Athlete Triad

- Refers to the interrelationships among energy availability, menstrual function, and bone mineral density
- Occurs more frequently in sports that emphasize leanness.
- Athletes at greatest risk for low energy availability
  - Restrict dietary energy intake
  - Exercise for prolonged periods
  - Vegetarian
  - Limit the types of food they will eat
- Most effects appear to occur below an energy availability of 30 kcal·kg