Chapter 10: Nutrition, Fitness and Physical Activity
Student learning outcomes: At the end of this chapter, you should be able to:

- Describe the benefits and risks of exercise
- Plan an exercise program for fitness, disease prevention, weight maintenance, or weight loss
- Plan dietary intake to support exercise
- Discuss pros and cons of supplements to improve performance
THINK about this – then share within a PAIR – then SHARE with the class

- What does it mean to be fit?
- What are the benefits of exercise?
- Which types of exercise are the best?
Fitness

- Set of attributes related to the ability to perform routine physical activities without undue fatigue

- Defined by: endurance, strength, flexibility, body composition

- Overload principle: adaptations in the body so that the body can do more
Cardiorespiratory endurance
Aerobic exercise

- lowers resting heart rate: heart pumps blood more efficiently, so it can pump less often
- increases aerobic capacity (VO$_2$ max): muscles’ ability to use oxygen to make ATP
- increases cardiorespiratory endurance: efficiency with which the body delivers oxygen and nutrients needed for muscular activity and transports waste products from cells
Muscle-strengthening exercise

- **Muscle strength:**
  enhances the ability to perform tasks such as pushing or lifting

- **Muscle endurance:**
  enhances the ability to continue repetitive muscle activity
Fitness

- Determines range of motion, improves performance in certain activities and may reduce risk of injuries
Body composition

- A physically fit person has a greater proportion of muscle and a smaller proportion of fat than an unfit person of the same weight.

- For young adult women, desirable body fat is 21–32% of total weight.

- In adult men, desirable amount is 8–19%.
Health benefits of exercise

Exercise improves flexibility and balance

Exercise increases the sensitivity of tissues to insulin and decreases the risk of developing type 2 diabetes.

Exercise reduces the risk of cardiovascular disease because it strengthens the heart muscle, lowers blood pressure, and increases HDL (good) cholesterol levels in the blood.

Regular exercise reduces the risk of colon cancer and breast cancer.

Exercise increases muscle mass, strength, and endurance.

Weight-bearing exercise stimulates bones to become denser and stronger and therefore reduces the risk of osteoporosis. The strength and flexibility promoted by exercise can help improve joint function.
Benefits of exercise

- Releases chemical endorphins: may enhance mood and aid in relaxation, pain tolerance, and appetite control
- Improves mood, self-esteem, vigor, overall well-being, quality of life
- Reduces depression and anxiety
Exercise & weight management

Exercise increases total energy expenditure through increased:

- energy output during exercise
- energy expenditure that persists for a period after exercise
- lean muscle mass: increases basal needs over the long term
Exercise & weight management

![Graph showing total energy expenditure (calories)]
Concept check

- What distinguishes a fit person from an unfit one?
- Why do your muscles get bigger when you lift weights?
- How does exercise affect heart health?
- How does exercise help with weight management?
Exercise recommendations

- 2010 Dietary Guidelines: ≥ 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic physical activity each week or an equivalent combination of both

  - **Moderate-intensity exercise** = walking 3 miles/hour or bicycling 8 miles/hour

  - **Vigorous-intensity exercise** = jogging ≥ 5 miles/hour or bicycling ≥ 10 miles/hour

- Muscle-strengthening activities ≥ 2 days/week
Exercise recommendations

- Every day: Be as active as possible
  - Walk to the store or school
  - Take the stairs
  - Walk the dog
  - Garden
  - Park your car farther away
  - Do housework
  - Do yard work
  - Play with children

- Minimize sedentary activities
  - Watching TV
  - Playing video games

- 3 days/week: Aerobic activities
  - Running
  - Walking
  - Swimming
  - Biking
  - Cross-country skiing
  - Jumping rope
  - Soccer
  - Basketball
  - Tennis
  - Volleyball
  - Football
  - Rowing

- 2 to 3 days/week: Strength and flexibility
  - Sit-ups
  - Pilates
  - Push-ups
  - Yoga
  - Weight lifting
  - Bowling
  - Stretching
  - Stair climbing
  - Sit-ups
  - Tai chi
  - Golf
  - Canoeing

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**Recommendation**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Intensity</th>
<th>Frequency/Duration</th>
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<tr>
<td>Aerobic</td>
<td>Moderate: Raise heart rate to 60 to 69% of maximum or Vigorous: Raise heart rate to 70 to 85% of maximum</td>
<td>5 to 7 days/week for 30 to 60 minutes or 3 to 7 days/week for 25 to 60 minutes</td>
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<tr>
<td>Muscle strengthening</td>
<td>Use weights that are heavy enough for muscles to be near exhaustion after 10 to 12 repetitions</td>
<td>2 to 3 nonconsecutive days/week, 8 to 10 exercises for all major muscle groups, repeat each lift 8 to 12 times</td>
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<tr>
<td>Flexibility</td>
<td>Extend to position of mild discomfort</td>
<td>2 to 7 days/week, hold each stretch for 10 to 30 seconds, and repeat each stretch 3 to 5 times</td>
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Aerobic zone

- **Aerobic activity**: raises heart rate to 60–85% of maximum heart rate

- **Aerobic zone**: exercise at an intensity in this range
Aerobic zone

- Heart rate (beats/min)
  - Maximum heart rate
  - 85% of maximum
  - 60% of maximum

- Age (years)

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Creating an active lifestyle

How can you incorporate exercise in YOUR life to meet recommendations and goals?
Creating an active lifestyle

Suggestions for starting and maintaining an exercise program  Table 10.1

Start slowly. Set specific, attainable goals. Once you have met them, add more

- Walk around the block after dinner.
- Get off the bus or subway one stop early.
- Use half of your lunch break to exercise.
- Do a few biceps curls each time you take the milk out of the refrigerator.

Make your exercise fun and convenient

- Opt for activities you enjoy: Bowling and dancing may be more fun for you than using a treadmill at the gym.
- Find a partner to exercise with you.
- Choose times that fit your schedule.

Stay motivated

- Vary your routine: Swim one day and mountain bike the next.
- Challenge your strength or endurance once or twice a week and do moderate workouts on other days.
- Track your progress by recording your activity.
- Reward your success with a new book, movie, or workout clothes.

Keep your exercise safe

- Warm up before you start.
- Cool down when you are done.
- Don’t overdo it: Alternate hard days with easy days and take a day off when you need it.
- Listen to your body and stop before an injury occurs.
Over Training Syndrome

- Excessive training without sufficient rest to allow for recovery

- Symptoms: fatigue that limits workouts and felt even at rest, decreased appetite, weight loss, muscle soreness, increased frequency of viral illnesses, increased incidence of injuries, mood changes, depression, altered sleep patterns, loss of competitive desire and enthusiasm
Concept check

- How much aerobic exercise is recommended to reduce the risk of chronic disease?
- What is your aerobic zone?
- What types of exercise should be part of a fitness program?
- Who is at risk for overtraining syndrome?
Anaerobic vs. aerobic metabolism
ATP production

- Anerobic metabolism: without oxygen
  - Only uses glucose // generates lactic acid

- Aerobic metabolism: with oxygen
  - Uses carbohydrates, protein, and fat
  - More efficient; produces more ATP per glucose
  - Occurs in mitochondria (the powerhouse of the cell)
Oxygen delivery

1. Inhaled oxygen is transferred from the lungs to the blood.
2. The cardiovascular system circulates the oxygen-rich blood throughout the body.
3. Oxygen is taken up by the muscles and other tissues and used to generate ATP, producing carbon dioxide as a waste product.
4. Carbon dioxide is carried away from the muscle by the blood.
5. Carbon dioxide is exhaled through the lungs.
Exercise duration & fuel use

**Instant energy**
During the first few seconds of exercise, the muscles get energy from stored ATP. Then, for the next 10 seconds or so, creatine phosphate stored in the muscles is broken down to form more ATP.

**Short-term energy**
Anaerobic metabolism of glucose, obtained either from the blood or from muscle glycogen, becomes the predominant source of ATP when creatine phosphate stores have been depleted. Thirty seconds into the activity, anaerobic pathways are operating at full capacity.

**Long-term energy**
After about two to three minutes, oxygen delivery to the muscles has increased enough to support aerobic metabolism, which uses fatty acids and glucose to produce ATP.
Exercise duration & fuel use

- First few seconds of exercise:
  - Stored ATP is used then
  - Creatine phosphate is broken down to make ATP

- After about 15 seconds of exercise:
  - Anaerobic metabolism uses glucose to make ATP

- After 2–3 minutes of exercise:
  - Breathing and heart rate have increased
  - Aerobic metabolism uses glucose to make ATP
Exercise duration & fuel use

Liver glycogen and glucose synthesis by the liver

Dietary carbohydrate

Muscle glycogen

Blood glucose

Dietary protein

Body protein

Adipose tissue

Triglycerides in muscle

Glucose

Amino acids

Fatty acids

Anaerobic metabolism

Aerobic metabolism

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What a scientist sees
Exercise intensity & fuel use

- With low-intensity activity: ATP produced from glucose and fatty acids by aerobic metabolism

- With intense exercise:
  - More ATP is needed
  - Oxygen delivery to and use by muscles limited
  - Muscles make ATP by anaerobic metabolism
Exercise intensity & fuel use

Percentage of ATP from different nutrients

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<th>Rest</th>
<th>Moderate-intensity activity</th>
<th>High-intensity activity</th>
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<tr>
<td>Fatty acids</td>
<td>60</td>
<td>40</td>
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<td>Glucose</td>
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Fatigue

- Inability to continue activity at optimal level

- Occurs when glycogen stores are depleted
  
  - Occurs much more quickly with high-intensity exercise because it relies more on anaerobic metabolism, which only uses glucose
Fatigue: hitting the wall

Between 60 and 120 grams of glycogen are stored in your liver; glycogen stores are highest just after a meal. Liver glycogen is used to maintain blood glucose between meals and during the night. Eating a high-carbohydrate breakfast will replenish the liver glycogen you used while you slept.

There are about 200 to 500 g of glycogen in the muscles of a 70-kg (154-lb) person. The glycogen in a muscle is used to fuel that muscle’s activity.
Fitness training & fuel use

Cardiac output (Liters of blood/minute)

Trained | Untrained

Mitochondria

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Lactic Acid

- Produced during **anaerobic metabolism**

- During low-intensity exercise:
  - Small amounts produced are carried away from muscles and used by other tissues as an energy source or converted back into glucose by the liver

- During high-intensity exercise:
  - Builds up in muscle then blood since amount produced > amount used by other tissues
  - Not a major factor in muscle fatigue
Concept check

- What fuels are used in anaerobic metabolism?

- What type of metabolism does a marathon runner rely on?

- Why is a trained athlete able to perform at a higher intensity for a longer time than an untrained person?
Diet needs for physical activity

- Energy to fuel activity // Amount of energy expended for any activity depends on the intensity, duration, and frequency of the activity and the weight of the exerciser

- Protein to maintain muscle mass

- Micronutrients to permit use of energy-yielding nutrients

- Water to transport nutrients and cool the body
Energy expenditure during exercise

![Bar graph showing energy expenditure during exercise at different body weights and running paces.](chart)

- **Running pace**
  - 12 min/mi
  - 6 min/mi

**Energy expenditure (Calories/hour)**

- **125 pounds**
  - 6 min/mi: ~600 Calories/hour
  - 12 min/mi: ~300 Calories/hour

- **170 pounds**
  - 6 min/mi: ~1000 Calories/hour
  - 12 min/mi: ~500 Calories/hour

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Gaining or losing weight

- Healthy weight gain:
  - Combination of increased energy intake, adequate protein intake, and muscle-strengthening exercise to promote an increase in lean tissue vs. fat

- Healthy weight loss:
  - Reduce energy intake by 200 to 500 Calories/day, increase activity, and change the behaviors that led to weight gain
Female athletic triad

Low energy intake reduces the intake of calcium and other nutrients important for bone health.

Disordered Eating

The extreme energy restriction of an eating disorder combined with exercise creates a physiological condition that is similar to starvation, which contributes to a drop in estrogen levels. Low estrogen causes amenorrhea.

Osteoporosis

Amenorrhea

Estrogen is needed for calcium homeostasis in the bone and for calcium absorption in the intestines. Low levels lead to low peak bone mass, premature bone loss, and increased risk of stress fractures.
Making weight
Macronutrient needs for physically-active individuals

- Carbohydrates: 6–10 g of carbohydrate / kg of body wt/day
- Fat: 20-35% of calories // Same as needs for the general population
- Protein: 15–20% of calories
  - To maintain and repair lean tissues (e.g., muscle)
  - Endurance athletes: 1.2–1.4 g of protein/kilogram of body weight/day
  - Strength training: 1.2–1.7 g/kg/day
Macronutrient needs

The majority of calories should come from carbohydrate. Most of the carbohydrate should be from nutrient-dense choices such as whole grains, fruits, vegetables, and low-fat dairy products.

Dietary fat is essential for health even though body fat stores contain enough energy to fuel even the longest endurance events. Most dietary fat should be from sources high in heart-healthy mono- and polyunsaturated fats.

The protein needs of athletes, can be met with either plant or animal sources.
Vitamin & mineral needs for physically-active individuals

- Same as needs for the general population
- Needed for energy production, oxygen delivery, protection against oxidative damage, and repair and maintenance of body structures
- Increased use and loss with exercise
- DRIs acknowledge that the iron requirement may be 30 to 70% higher for athletes than for the general population
Sports anemia

Normal

Sports anemia
Water needs for physically-active individuals

- Exercise increases water needs because it increases losses in sweat and respiratory system evaporation.

- Risk of dehydration is greater in hot than cold environments but can occur in the cold.

- Water is needed to cool the body and transport oxygen and nutrients to the muscles and remove waste products from them.
Dehydration & performance

If a person loses 4% of their body weight as water during a competition, by what percentage will their performance be decreased by the end of the event?

a) It will not be affected
b) 10%
c) 20%
d) 25%
e) 30%
Dehydration

- Occurs when water loss is great enough for blood volume to decrease
  - Reduces the ability of the circulatory system to deliver oxygen and nutrients to muscles
  - Reduces blood flow to the skin and sweat production limiting the body’s ability to cool itself
  - Can increase core body temperature and heat-related illnesses
Heat-related illnesses

- **Heat cramps**: involuntary muscle spasms during or after intense exercise

- **Heat exhaustion**: Decreased blood volume, ability to cool the body and oxygen delivery
  - Rapid but weak pulse, low blood pressure, disorientation, profuse sweating, fainting

- **Heat stroke**: core body temperature rises above 105°F causing decreased sweating
  - Hot, dry skin; extreme confusion; unconsciousness
# Heat index

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**With prolonged exposure and/or physical activity**

- Extreme danger
- Heat stroke highly likely
- Danger
- Heat stroke, heat cramps, and/or heat exhaustion likely
- Extreme caution
- Heat stroke, heat cramps, and/or heat exhaustion possible
- Caution
- Fatigue possible
Hyponatremia

- Decreased blood sodium
  - Early symptoms: nausea, muscle cramps, disorientation, slurred speech, confusion
  - Can cause water to move from blood to tissues by osmosis causing swelling
    - In the lungs: interferes with gas exchange
    - In the brain: causes disorientation, seizure, coma, death
  - Sweating results in loss of sodium
    - During endurance events, sweat needs to be replaced with water AND sodium
Hyponatremia

Normal blood sodium concentration

Water and sodium lost in sweat

Replacing just water dilutes sodium (hyponatremia)
Fluid recommendations for exercise

- Generous amounts of fluid in the 24 hours before an exercise session
- About 2 cups of fluid 4 hours before exercise
- 6–12 ounces of fluid every 15–20 minutes for the duration of the exercise
- After exercise, each pound of weight lost should be replaced with 16–24 oz (2 to 3 cups)
Fluid recommendations for exercise

- For exercise lasting an hour or less, water is the only fluid needed.

- For exercise lasting more than an hour, beverages containing carbohydrate (about 10 to 20 g of carbohydrate/cup) and electrolytes (around 150 milligrams of sodium in a cup) are recommended.

  - Fruit juices and soft drinks are not recommended unless diluted with an equal volume of water.
Dietary carbohydrate & endurance

- Low-carbohydrate diet
- Normal diet
- High-carbohydrate diet

Time to exhaustion (min)

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Glycogen super-compensation

- To substantially increase muscle glycogen stores before competition

- Rest for 1–3 days before competition while consuming a very high-carbohydrate diet
  - 10–12 g carbohydrate/kilogram of body weight/day

- Beneficial to endurance athletes

- Disadvantages if exercising < 90 minutes
What to eat before exercise

- Enough fluid to maintain hydration
- High in carbohydrate (60 to 70% of calories)
- Contain about 300 Calories
- Moderate in protein (10 to 20%)
- Low in fat (10 to 25%)
- Low in fiber
- Avoid spicy foods
- Avoid large amounts of simple sugars
What to eat before exercise
What to eat during exercise lasting more than an hour

- Consume carbohydrate
  - Particularly important for exercise in the morning, when liver glycogen levels are low
  - Carbohydrate intake should begin shortly after exercise begins
  - Regular amounts should be consumed every 15–20 minutes during exercise, about 30–60 grams/hour
  - Should provide glucose and fructose

- Consume sodium
What to eat after exercise

- Replace lost fluids

- Replace glycogen stores:
  - For 30–60 minutes of daily exercise, a typical diet with about 55% of calories is sufficient
  - For serious athletes competing on consecutive days, a high-carbohydrate meal or drink (1–1.5 g of easily absorbed carbohydrate per kilogram of body weight) should be consumed within 30 minutes and every 2 hours for about 6 hours
Concept check

- Why might a low-carbohydrate diet be a poor choice for an endurance athlete?

- Why is dehydration more likely when it is hot and humid?

- How much of what fluid should you drink during a two-hour bike ride?

- What should a athlete eat as a precompetition meal and why?
Ergogenic aids

- Substances, appliances, or procedures that improve athletic performance

- Many vitamins, minerals, and substances in these supplements help provide energy for exercise or promote exercise recovery

- Most do not improve athletic performance; a few have a small effect compared a healthy diet

- Most are promoted based on their function, but supplementation does not improve function
Diet, supplements & performance

An overall healthy diet

Ergogenic supplements

Sports foods and beverages

Andy Washnik

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Growth hormone (GH)

- Increases muscle protein synthesis but has not been shown to enhance muscle strength, power, or aerobic exercise capacity

- Improves anaerobic exercise capacity

- Can cause heart dysfunction, high blood pressure, excessive growth of some body parts

- Ornithine, arginine, and lysine stimulate GH release but do not cause muscle mass/strength increases more than exercise alone
Anabolic steroids

- Synthetic fat-soluble hormones that mimic testosterone
- Accelerate protein synthesis
- Increase muscle size and strength
- Steroid precursors (e.g., androstenedione, or andro) can be converted into steroids in the body but have not been found to increase testosterone levels or have ergogenic effects
Anabolic steroids – side effects

- Decrease testosterone secretion leading to testicle shrinkage and decreased sperm production

- Stunted height in adolescents

- Oily skin, acne, water retention in the tissues, yellowing of the eyes and skin, coronary artery disease, liver disease, death, psychological and behavioral changes (violent outbursts, depression, suicide)
Anabolic steroids – side effects
Ergogenic aids in short, intense activities

- **β-hydroxy-β-methylbutyrate (HMB):** studies found a small increase in strength in previously untrained men; trivial effects in trained lifters

- **Bicarbonate:** acts as a buffer to neutralize acid to delay fatigue and improve performance
  - Causes abdominal cramps and diarrhea

- **Creatine:** used to make creatine phosphate to provide quick energy for short-term maximal exercise; may increase muscle mass/strength
Creatine

Creatine from the diet or from supplements

Creatine synthesized in the body

Creatine phosphate

ADP

ATP
Ergogenic aids in endurance activities

- Increase fat or oxygen available to muscle cells

- **Carnitine**: fat burner - increases fat utilization during exercise to spare glycogen; supplements have not been shown to increase endurance

- **Medium-chain triglycerides (MCT)**: cause blood fatty acids levels to rise increasing availability of fat as a fuel; supplements have not been shown to increase endurance, spare glycogen, or enhance performance
Ergogenic aids in endurance activities

- **Caffeine**: enhances fatty acids release to use as a fuel source so less glycogen is used and fatigue onset is delayed.

- Improves concentration, enhances alertness.

- May impair performance by causing GI upset.

- 3–6 mg of caffeine per kilogram of body weight (about 2.5 cups of coffee) up to an hour before exercising and smaller doses during exercise (1 to 2 mg/kg) improve endurance.
Debate

Are Energy Drinks a Good Way to Enhance Athletic Performance?

<table>
<thead>
<tr>
<th>Caffeine content</th>
<th>Serving (fluid ounces)</th>
<th>Caffeine (mg)</th>
<th>Sugar (g)</th>
<th>Energy (calories)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beverage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>8</td>
<td>100–200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Espresso with sugar</td>
<td>1.5</td>
<td>100</td>
<td>15–30</td>
<td>60–120</td>
</tr>
<tr>
<td>Coca-Cola Classic</td>
<td>12</td>
<td>35</td>
<td>39</td>
<td>140</td>
</tr>
<tr>
<td>Mountain Dew</td>
<td>12</td>
<td>54</td>
<td>46</td>
<td>170</td>
</tr>
<tr>
<td>Monster</td>
<td>16</td>
<td>160</td>
<td>54</td>
<td>200</td>
</tr>
<tr>
<td>Jolt Cola</td>
<td>8</td>
<td>80</td>
<td>30</td>
<td>120</td>
</tr>
<tr>
<td>Arizona Caution Extreme Energy Shot</td>
<td>8</td>
<td>100</td>
<td>33</td>
<td>130</td>
</tr>
<tr>
<td>Red Bull</td>
<td>8</td>
<td>80</td>
<td>28</td>
<td>110</td>
</tr>
<tr>
<td>Rockstar</td>
<td>16</td>
<td>160</td>
<td>62</td>
<td>280</td>
</tr>
<tr>
<td>Monster</td>
<td>8</td>
<td>80</td>
<td>27</td>
<td>100</td>
</tr>
<tr>
<td>Full Throttle</td>
<td>16</td>
<td>160</td>
<td>57</td>
<td>220</td>
</tr>
</tbody>
</table>
Erythropoietin (EPO)

- Produced by the kidneys to stimulate red blood cell production

- Can enhance endurance by increasing the ability to transport oxygen to the muscles to increase aerobic capacity and spare glycogen

- Too much can stimulate too many red blood cells leading to blood clotting, heart attacks, strokes, death
Concept check

- How do anabolic hormones affect the production of testosterone?
- Why are creatine supplements beneficial for sprint and strength athletes?
- How does caffeine increase endurance?
Applications

What advice could you give about food, water, and supplement consumption to a friend who is an athlete?
Nutrition in the news

- Energy drinks
- Energy drinks + alcohol
- Making weight
- Eating disorders in athletes
- Steroids in baseball and other sports
- Banned substances in cycling, track and field, and other sports
Checking student learning outcomes

- What are the benefits and risks of exercise?

- Which types of exercise programs could you follow for fitness, disease prevention, weight maintenance, or weight loss?

- What advice would you give to a loved one about dietary intake to support exercise?

- What are the pros and cons of supplements to improve performance?