Fluid and Energy Replacement during Prolonged Exercise

Prolonged exercise, typically lasting longer than 90 minutes, places significant demands on the body's energy stores, fluid balance, and electrolytes. Inadequate replacement of these can impair performance, reduce endurance, and increase the risk of heat-related illnesses and dehydration. Proper fluid and energy replacement during extended physical activity are crucial for maintaining optimal performance, preventing fatigue, and supporting recovery. The mechanisms of fluid and energy replacement during prolonged exercise, the factors influencing hydration and energy needs, and guidelines for effective replenishment are as follows,

1. Fluid Replacement

a) Fluid Loss during Prolonged Exercise

During prolonged exercise, the body loses fluids primarily through sweating and respiratory evaporation. The rate of fluid loss depends on several factors, including:

- **Exercise intensity and duration:** Higher intensity and longer duration lead to greater fluid loss.
- **Environmental conditions:** Hot and humid environments increase sweat rate and fluid loss.
- **Individual factors:** Factors such as fitness level, adaptation to heat, and sweat rate variability can influence fluid loss.

Sweat rates during prolonged exercise can range from 0.5 to 2.0 L/h, and in extreme conditions, even higher rates may be observed. This loss of fluid, if not properly replaced, can lead to dehydration, which impairs thermoregulation, increases cardiovascular strain, and reduces exercise performance.

b) Dehydration and Performance Impairment

Dehydration of as little as 2% body mass can begin to impair exercise performance, with more significant impairments seen with greater levels of dehydration. These include:

- **Decreased endurance:** As dehydration increases, the body's ability to cool itself diminishes, leading to elevated core temperatures, increased perceived exertion, and decreased stamina.
- **Reduced muscle function:** Dehydration may impair the function of muscles due to changes in electrolyte balance, leading to cramping, weakness, and fatigue.
- **Cognitive impairment:** Dehydration can impair mental focus, decision-making, and coordination, which can be particularly dangerous in activities requiring skill and attention, such as cycling or running.

c) Fluid Replacement Strategy

To avoid dehydration, fluid should be replaced during prolonged exercise at a rate that matches the body's sweat rate. However, excessive fluid intake can lead to **hyponatremia**, a condition where blood sodium levels become dangerously low, leading to swelling in the brain and potentially fatal consequences.

Guidelines for fluid replacement include:

- **Before exercise:** Drink 400-600 mL of fluid 2-3 hours before exercise to optimize hydration levels.
- **During exercise:** Consume 150-250 mL of fluid every 15-20 minutes. The goal is to replace fluid losses without overloading the stomach, which can cause discomfort.
- **After exercise:** Replenish fluid loss with water or an electrolyte-containing beverage to ensure proper rehydration.

d) Electrolyte Balance

During prolonged exercise, especially in hot conditions, sodium, potassium, and other electrolytes are lost through sweat. Electrolyte imbalances can contribute to muscle cramps, dizziness, and fatigue. Replacing both fluids and electrolytes is essential for maintaining performance and preventing heat-related illnesses.

Electrolytes are commonly replaced through sports drinks, which contain a balance of sodium, potassium, and sometimes magnesium. The sodium content in sports drinks (typically **300-700 mg per 500 mL**) is particularly important for maintaining blood sodium levels and stimulating thirst to encourage continued fluid intake.

2. Energy Replacement

a) Energy Demands during Prolonged Exercise

The body relies on both carbohydrate and fat stores to fuel prolonged exercise. Carbohydrates are stored as glycogen in the muscles and liver, while fat is stored in adipose tissue. As exercise duration increases, the body gradually shifts from using primarily carbohydrates to utilizing more fat as an energy source.

- **Carbohydrates:** Glycogen provides a rapid and easily accessible energy source. However, muscle and liver glycogen stores are limited, typically providing enough fuel for 90-120 minutes of moderate to high-intensity exercise.
- **Fats:** Fat oxidation increases as exercise duration increases. However, fat is a slower and less efficient energy source than carbohydrates for high-intensity exercise.

b) Glycogen Depletion and Performance Impairment

The depletion of glycogen stores during prolonged exercise, often referred to as **“hitting the wall” or "bonking,"** results in extreme fatigue, a significant reduction in performance, and even an inability to continue exercise. Glycogen **depletion typically occurs after 1.5 to 2 hours of moderate to intense exercise,** particularly in individuals who have **not sufficiently fueled before or during the exercise.**

c) Carbohydrate Intake during Exercise

To avoid glycogen depletion and prolong endurance performance, carbohydrates should be consumed during prolonged exercise. The optimal rate of carbohydrate consumption varies based on the exercise intensity, but research suggests that **ingesting 30-60 grams of carbohydrates per hour** during exercise can help maintain blood glucose levels and spare

muscle glycogen. Higher rates of carbohydrate consumption (**up to 90 grams per hour**) may be beneficial for ultra-endurance events.

Sources of carbohydrates during exercise include:

- **Sports drinks:** Provide both hydration and carbohydrate, typically in the form of glucose or sucrose.
- **Energy gels or chews:** Compact and easily digestible sources of carbohydrates.
- **Solid foods:** In longer events (e.g., ultra-marathons), athletes may consume bars, fruits, or sandwiches.

d) Post-Exercise Carbohydrate and Protein Recovery

After exercise, it is important to replenish glycogen stores and support muscle repair. A combination of carbohydrates and protein (typically in **a 3:1 or 4:1 carbohydrate-to-protein ratio**) should be consumed within 30-60 minutes post-exercise. The carbohydrates will help restore glycogen stores, while the protein aids in muscle repair and recovery.

3. Recommendations for Fluid and Energy Replacement

- **Hydration:** Aim for regular fluid intake during prolonged exercise, adjusting according to sweat rate and environmental conditions. Consider using electrolyte-containing drinks in hot and humid conditions.
- **Carbohydrate Intake:** Consume 30-60 grams of carbohydrates per hour, depending on exercise intensity, and consider higher amounts for ultra-endurance events.
- **Pre-Exercise Nutrition:** Consume a carbohydrate-rich meal 3-4 hours before exercise and hydrate well before starting.
- **Post-Exercise Recovery:** Rehydrate with fluids containing electrolytes and consume a carbohydrate-protein recovery meal within 30-60 minutes of completing the exercise.

References:

1. American College of Sports Medicine (ACSM). (2016). *Position Stand: Exercise and Fluid Replacement*. Medicine & Science in Sports & Exercise, 48(4), 543-563.
2. Jeukendrup, A. E. (2014). *Nutrition for endurance sports: marathon, triathlon, and road cycling*. Journal of Sports Sciences, 32(1), 16-23.
3. Maughan, R. J., & Shirreffs, S. M. (2010). *Hydration and performance in the heat: an overview*. Journal of Sports Sciences, 28(S1), S41-S48.
4. Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). *Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance*. Journal of the Academy of Nutrition and Dietetics, 116(3), 501-528.