

Unit 10

Water and Electrolytes

1. Distribution, functions of water in the body
 2. Water turnover and balance
 3. Electrolyte composition of the body fluids, Dietary intake of electrolyte and Electrolyte balance
 4. Dehydration, causes of dehydration and oral rehydration therapy
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Water is essential for life and plays crucial roles in various physiological functions within the human body. Here are some key aspects of water distribution and its functions

DISTRIBUTION & FUNCTION

Intracellular Fluid (ICF):

About two-thirds of the body's total water is found within cells.

Functions:

1. Provides a medium for cellular reactions and metabolic processes.
2. Helps maintain cell shape and structure.
3. Facilitates the movement of substances in and out of cells.

Extracellular Fluid (ECF):

- Comprises the remaining one-third of the body's water and is located outside cells.
- Divided into interstitial fluid (fluid between cells) and plasma (the liquid component of blood).

Functions:

1. Acts as a transport medium for nutrients, gases, hormones, and waste products.
2. Helps maintain blood volume and pressure.
3. Facilitates exchange of substances between blood and tissues.
4. Solvent for biochemical reactions:

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Temperature regulation:

1. Water has a high heat capacity, allowing it to absorb and release heat without significant changes in temperature.
2. Through processes like sweating and vasodilation, water helps dissipate heat from the body, contributing to temperature regulation.

Transport medium:

- Water is a key component of blood and lymph, facilitating the transport of nutrients, oxygen, hormones, and metabolic waste products throughout the body.

Electrolyte balance:

1. Water helps maintain the balance of electrolytes (such as sodium, potassium, chloride, calcium, and magnesium) in the body.
2. Electrolytes are essential for nerve function, muscle contraction, fluid balance, and maintaining pH levels.

Cushioning and lubrication:

Water provides cushioning and lubrication for vital organs, such as the brain and spinal cord (cerebrospinal fluid) and joints (synovial fluid).

Digestion and waste removal

Adequate water intake is essential for proper digestion, as it helps dissolve and transport nutrients, aids in the breakdown of food, and facilitates the movement of waste through the digestive tract.

Water turnover and balance refer to the dynamic equilibrium between water intake, water loss, and internal water distribution within the body. It is crucial for maintaining proper hydration levels and overall health. Here's a breakdown of water turnover and balance:

WATER INTAKE

Water intake primarily comes from drinking fluids, but it also includes water obtained from food and metabolic processes.

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The amount of water intake varies based on factors such as age, body size, activity level, environmental conditions, and dietary habits.

Water Loss

- Water loss occurs through various avenues, including urine, feces, sweat, respiration, and insensible losses (evaporation from the skin and respiratory tract).
- Urine accounts for the largest proportion of water loss, followed by insensible losses and sweat. Feces typically contain a smaller amount of water.
- Factors such as physical activity, ambient temperature, humidity, and health status can influence the rate of water loss.

Regulation of Water Balance:

- The body maintains water balance through complex regulatory mechanisms involving hormones, the kidneys, and the nervous system.
- Hormones such as antidiuretic hormone (ADH) and aldosterone help regulate water retention and excretion by influencing kidney function.
- Thirst sensation, triggered by changes in blood osmolality and volume, prompts individuals to consume fluids when needed to maintain hydration.
- The kidneys play a central role in regulating water balance by adjusting urine volume and concentration based on hydration status.

Water Turnover

- Water turnover refers to the rate at which water is replaced within the body over a given period.
- It is calculated by dividing the total volume of water consumed or eliminated (output) by the duration of time.
- The turnover rate varies among individuals and can be influenced by factors such as fluid intake, physical activity, metabolic rate, and environmental conditions.

Hydration Status

- Hydration status reflects the balance between water intake and water loss.
- Adequate hydration is essential for maintaining physiological functions, cognitive performance, thermoregulation, and overall health.
- Dehydration occurs when water loss exceeds intake, leading to symptoms such as thirst, dry mouth, dark urine, fatigue, and impaired cognitive function. Chronic dehydration can have detrimental effects on health and may increase the risk of kidney stones, urinary tract infections, and other complications.

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ELECTROLYTES COMPOSITION OF THE BODY FLUIDS

Electrolytes are minerals that have an electric charge when they are dissolved in water or body fluids, including blood. The electric charge can be positive or negative and present in blood, urine (pee), tissues, and other body fluids.

Electrolytes are important because they help:

- Balance the amount of water in your body
- Balance the body's acid/base (pH) level
- Move nutrients into the cells
- Move wastes out of the cells
- Support your muscle and nerve function
- Keep heart rate and rhythm steady
- Keep blood pressure stable
- Keep bones and teeth healthy

The body fluids, including blood plasma, interstitial fluid, and intracellular fluid, contain various electrolytes that play crucial roles in maintaining physiological balance and proper function.

The primary electrolytes found in body fluids include:

1. **Sodium (Na⁺)**

Sodium is the primary cation in extracellular fluid (blood plasma and interstitial fluid). It is essential for maintaining fluid balance, nerve transmission, and muscle function.

2. **Potassium (K⁺)**

Potassium is the primary intracellular cation, playing a critical role in maintaining cell membrane potential, nerve transmission, and muscle contraction.

3. **Chloride (Cl⁻)**

Chloride is the major extracellular anion, often found in association with sodium. It helps maintain osmotic pressure, regulates fluid balance, and contributes to the acid-base balance.

4. **Calcium (Ca²⁺):**

Calcium is primarily found in bones and teeth, but it also plays vital roles in muscle contraction, nerve transmission, blood clotting, and cell signaling.

5. **Magnesium (Mg²⁺)**

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Magnesium is involved in numerous biochemical reactions within the body, including energy metabolism, protein synthesis, muscle and nerve function, and maintaining bone health.

6. Phosphate (PO_4^{3-})

Phosphate is essential for energy metabolism (as ATP), bone and teeth mineralization, and buffering systems that help maintain acid-base balance.

7. Bicarbonate (HCO_3^-)

Bicarbonate is a crucial buffer in the body, helping to maintain acid-base balance in blood plasma and other body fluids.

8. Sulfate (SO_4^{2-})

Sulfate is involved in various metabolic processes and is a component of some amino acids and proteins.

Dietary intake of electrolyte and Electrolyte balance

Electrolyte	Dietary Sources	Recommended Daily Intake (Adults)	Physiological Uses
Sodium (Na^+)	Table salt (sodium chloride),	Less than 2,300 mg per day,	Maintains fluid balance, nerve transmission, muscle
	processed foods, canned soups,	ideally no more than 1,500 mg/day	contraction, regulates blood pressure.
	condiments, fast food, snack foods		
Potassium (K^+)	Bananas, oranges, potatoes,	3,400-4,700 mg per day	Maintains fluid balance within cells, nerve transmission,
	sweet potatoes, spinach, tomatoes,		muscle contraction (including heart), blood pressure
	avocados, beans, yogurt, salmon.		regulation.
Calcium (Ca^{2+})	Dairy products (milk, cheese,	1,000-1,300 mg per day	Essential for bone and teeth health, muscle function,
	yogurt), fortified plant-based		nerve transmission, blood clotting, enzyme function.
	milk (soy milk, almond milk),		
	leafy greens (kale, collard greens)		

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Electrolyte	Dietary Sources	Recommended Daily Intake (Adults)	Physiological Uses
Magnesium (Mg ²⁺)	Nuts (almonds, cashews),	310-420 mg per day	Involved in energy production, muscle and nerve function, protein synthesis, bone health.
	seeds (pumpkin seeds, sunflower		
	seeds), whole grains (brown rice, oats, quinoa), leafy greens		
Phosphate (PO ₄ ³⁻)	Meat, poultry, fish, dairy	No specific recommendation	Essential for energy metabolism, bone and teeth mineralization, cell signaling, acid-base balance.
	products, nuts, legumes, whole		
	grains, eggs.		

ELECTROLYTE BALANCE

Electrolyte balance in the body refers to the maintenance of appropriate concentrations of electrolytes within bodily fluids, such as blood plasma, interstitial fluid (fluid between cells), and intracellular fluid (fluid inside cells).

Several mechanisms work together to ensure electrolyte balance:

Kidney Function: The kidneys play a crucial role in regulating electrolyte balance by filtering electrolytes from the blood and either reabsorbing them back into the bloodstream or excreting them in urine. Hormones such as aldosterone, produced by the adrenal glands, help regulate electrolyte reabsorption in the kidneys. For example, aldosterone increases sodium reabsorption and potassium excretion.

Hormonal Regulation: Hormones such as aldosterone, antidiuretic hormone (ADH), and parathyroid hormone (PTH) help regulate electrolyte balance. Aldosterone promotes sodium retention and potassium excretion in the kidneys, ADH regulates water reabsorption in the kidneys, and PTH helps regulate calcium and phosphate levels in the blood.

Intestinal Absorption: Electrolytes are absorbed from the gastrointestinal tract into the bloodstream through the process of digestion. The absorption of electrolytes such as sodium, potassium, calcium, and magnesium occurs primarily in the small intestine.

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Sweat and Other Losses: Electrolytes can be lost from the body through sweat, urine, feces, and other bodily fluids. During sweating, especially in hot environments or during physical activity, significant amounts of electrolytes, particularly sodium and chloride, are lost. It's essential to replenish these electrolytes through hydration and diet.

Dietary Intake: Consuming a balanced diet that includes foods rich in electrolytes, such as fruits, vegetables, dairy products, and lean proteins, helps maintain electrolyte balance. However, excessive intake of certain electrolytes, particularly sodium, can disrupt this balance and lead to health problems such as hypertension and fluid retention.

DEHYDRATION

Dehydration occurs when the body loses more fluids than it takes in, leading to an imbalance in the body's electrolytes. This imbalance can disrupt normal bodily functions. There are several causes of dehydration, including:

1. **Inadequate Fluid Intake:** Not drinking enough water or fluids, especially in hot weather or during physical activity, can lead to dehydration.
2. **Excessive Sweating:** Prolonged physical activity, high temperatures, or fever can cause excessive sweating, leading to fluid loss and dehydration.
3. **Diarrhea:** Diarrheal illnesses can lead to significant fluid and electrolyte loss, especially if the condition is severe or prolonged.
4. **Vomiting:** Persistent vomiting can result in fluid loss and electrolyte imbalances, increasing the risk of dehydration.
5. **Frequent Urination:** Conditions such as diabetes, certain medications, or excessive alcohol consumption can cause frequent urination, leading to fluid loss and dehydration.
6. **Fever:** Elevated body temperature due to fever increases sweating and fluid loss, potentially resulting in dehydration.
7. **Medical Conditions:** Certain medical conditions, such as kidney disease, diabetes insipidus, and adrenal gland disorders, can impair the body's ability to regulate fluid balance, increasing the risk of dehydration.
8. **Burns:** Severe burns can damage the skin's protective barrier, leading to fluid loss through the damaged skin, increasing the risk of dehydration.
9. **Age:** Infants, young children, and older adults are at higher risk of dehydration due to factors such as higher surface area to volume ratio (infants), inability to communicate thirst (infants and elderly), or decreased kidney function (elderly).
10. **Excessive Alcohol Consumption:** Alcohol is a diuretic, meaning it increases urine production, leading to fluid loss and dehydration, especially if not compensated by adequate water intake.

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ORAL REHYDRATION THERAPY (ORT)

- Oral rehydration therapy (ORT) is a simple and effective treatment for dehydration caused by conditions such as diarrhea, vomiting, or excessive sweating.
- It involves administering a solution of water, salts, and sugar orally to replenish lost fluids and electrolytes.
- ORT is especially crucial in managing dehydration, particularly in resource-limited settings or during outbreaks of diarrheal diseases, where access to intravenous fluids may be limited.

COMPOSITION OF ORAL REHYDRATION SOLUTION (ORS):

Water: ORS provides water to replace fluids lost through dehydration.

Electrolytes: ORS contains electrolytes such as sodium, potassium, chloride, and bicarbonate to replace those lost during dehydration. The precise electrolyte concentrations help restore the body's electrolyte balance.

Sugar: ORS typically contains glucose or sucrose to facilitate the absorption of electrolytes and water in the intestine. The sugar helps enhance the absorption of sodium and water through the intestinal wall.

Preparation and Administration:

1. ORS solutions are available in pre-packaged sachets or can be prepared using readily available ingredients at home. The World Health Organization (WHO) recommends a specific formula for preparing ORS solutions, typically involving mixing specific amounts of salt, sugar, and water.
2. The ORS solution is administered orally in small, frequent sips to prevent vomiting and encourage absorption. It's essential to continue ORS administration until dehydration is adequately corrected and normal hydration status is restored.

Benefits of Oral Rehydration Therapy:

- **Cost-Effective:** ORT is a cost-effective and accessible treatment option, especially in resource-limited settings where access to intravenous fluids may be limited.
- **Easy to Administer:** ORS solutions are simple to prepare and can be administered by caregivers, even in community settings or at home.
- **Effective in Mild to Moderate Dehydration:** ORT is effective in treating mild to moderate dehydration caused by conditions such as diarrhea, vomiting, or excessive sweating.

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- **Reduces Morbidity and Mortality:** Prompt administration of ORT can help prevent complications associated with dehydration and reduce the risk of morbidity and mortality, especially in vulnerable populations such as infants and young children.

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