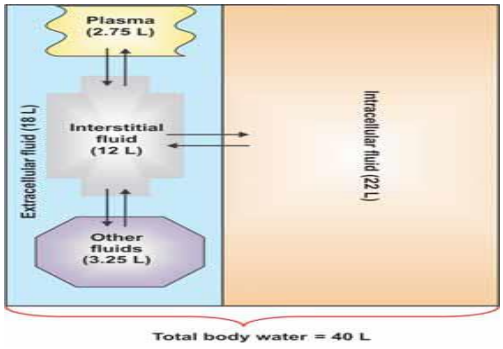
Body Fluids

Body is formed by solids and fluids. The fluid part is more than 2/3 of the whole body. Water forms most of the fluid part of the body. In human beings, the total body water (TBW) varies from 45 to 75% of body weight. In a normal young adult male, body contains 60 to 65% of water and 35 to 40% of solids. In a normal young adult female, the water is 50 to 55% and solids are 45 to 50%. The total quantity of body water in an average human being weighing about 70 kg is about 40 L.

COMPARTMENTS OF BODY FLUIDS

Total Body Water (40L) is distributed into two major fluid compartment

1. Intracellular fluid (ICF) forming 55% of the total body water (22 L).
2. Extracellular fluid (ECF) forming 45% of the total body water (18 L).



Body fluid compartments and movement of fluid between different compartments.
Other fluids = transcellular fluid, fluid in bones and fluid in connective tissue

Extracellular Fluid—The "Internal Environment"

About 60 percent of the adult human body is fluid, mainly a water solution of ions and other substances. Although most of this fluid is inside the cells and is called intracellular fluid, about one third is in the spaces outside the cells and is called extracellular fluid. This extracellular fluid is in constant motion throughout the body. It is transported rapidly in the circulating blood and then mixed between the blood and the tissue fluids by diffusion through the capillary walls. In the extracellular fluid are the ions and nutrients needed by the cells to maintain cell life. Thus, all cells live in essentially the same environment—the extracellular fluid. For this reason, the extracellular fluid is also called the internal environment of the body.

The extracellular fluid contains large amounts of sodium, chloride, and bicarbonate ions plus nutrients for the cells, such as oxygen, glucose, fatty acids, and amino acids. It also contains carbon dioxide that is being transported from the cells to the lungs to

be excreted, plus other cellular waste products that are being transported to the kidneys for excretion.

The intracellular fluid differs significantly from the extracellular fluid; specifically, it contains large amounts of potassium, magnesium, and phosphate ions instead of the sodium and chloride ions found in the extracellular fluid. Special mechanisms for transporting ions through the cell membranes maintain the ion concentration differences between the extracellular and intracellular fluids.

"Homeostatic" Mechanisms of the Major Functional Systems

The term homeostasis is used by physiologists to mean maintenance of nearly constant conditions in the internal environment. Essentially all organs and tissues of the body perform functions that help maintain these constant conditions.

Origin of Nutrients in the Extracellular Fluid

Respiratory System. Each time the blood passes through the body, it also flows through the lungs. The blood picks up oxygen in the alveoli, thus acquiring the oxygen needed by the cells. The membrane between the alveoli and the lumen of the pulmonary capillaries, the alveolar membrane, is only 0.4 to 2.0 micrometers thick, and oxygen diffuses by molecular motion through the pores of this membrane into the blood in the same manner that water and ions diffuse through walls of the tissue capillaries.

Gastrointestinal Tract.

A large portion of the blood pumped by the heart also passes through the walls of the gastrointestinal tract. Here different dissolved nutrients, including carbohydrates, fatty acids, and amino acids, are absorbed from the ingested food into the extracellular fluid of the blood.

Liver and Other Organs That Perform Primarily Metabolic Functions. Not all substances absorbed from the gastrointestinal tract can be used in their absorbed form by the cells. The liver changes the chemical compositions of many of these substances to more usable forms, and other tissues of the body—fat cells, gastrointestinal mucosa, kidneys, and endocrine glands—help modify the absorbed substances or store them until they are needed.

Musculoskeletal System. Sometimes the question is asked, how does the musculoskeletal system fit into the homeostatic functions of the body? The answer is obvious and simple: Were it not for the muscles, the body could not move to the appropriate place at the appropriate time to obtain the foods required for nutrition. The musculoskeletal system also provides motility for protection against adverse surroundings, without which the entire body, along with its homeostatic mechanisms, could be destroyed instantaneously.

Removal of Metabolic End Products

Removal of Carbon Dioxide by the Lungs. At the same time that blood picks up oxygen in the lungs, carbon dioxide is released from the blood into the lung alveoli; the respiratory movement of air into and out of the lungs carries the carbon dioxide to the atmosphere. Carbon dioxide is the most abundant of all the end products of metabolism.

Kidneys. Passage of the blood through the kidneys removes from the plasma most of the other substances besides carbon dioxide that are not needed by the cells. These substances include different end products of cellular metabolism, such as urea and uric acid; they also include excesses of ions and water from the food that might have accumulated in the extracellular fluid. The kidneys perform their function by first filtering large quantities of plasma through the glomeruli into the tubules and then reabsorbing into the blood those substances needed by the body, such as glucose, amino acids, appropriate amounts of water, and many of the ions. Most of the other substances that are not needed by the body, especially the metabolic end products such as urea, are reabsorbed poorly and pass through the renal tubules into the urine.

Regulation of Body Functions

Nervous System. The nervous system is composed of three major parts: the sensory input portion, the central nervous system (or integrative portion), and the motor output portion. Sensory receptors detect the state of the body or the state of the surroundings.

Hormonal system of Regulation

Located in the body are eight major endocrine glands that secrete chemical substances called hormones. Hormones are transported in the extracellular fluid to all parts of the body to help regulate cellular function.

Reproduction

Sometimes reproduction is not considered a homeostatic function. It does, however, help maintain homeostasis by generating new beings to take the place of those that are dying. This may sound like a permissive usage of the term homeostasis, but it illustrates that, in the final analysis, essentially all body structures are organized such that they help maintain the automaticity and continuity of life.

Control Systems of the Body

The human body has thousands of control systems in it.
The most intricate of these are the genetic control systems that operate in all cells to help control intracellular function as well as extracellular function.

APPLIED PHYSIOLOGY

DEHYDRATION

Definition

Significant decrease in water content of the body is known as dehydration.

Classification

Basically, dehydration is of three types:
1. Mild dehydration when fluid loss is about 5% of total body fluids.
2. Moderate dehydration when fluid loss is about 10%.
3. Severe dehydration when fluid loss is about 15%.

Causes

1. Severe diarrhea and vomiting
2. Excess water loss through urine
4. Insufficient intake of water
5. Excess sweating
6. Use of laxatives or diuretics.

Signs and Symptoms

Mild and moderate dehydration
1. Dryness of the mouth
2. Excess thirst
3. Decrease in sweating
4. Decrease in urine formation.

Severe dehydration
1. Decrease in blood volume
2. Decrease in cardiac output
3. Cardiac shock.

Very severe dehydration
1. Damage of organs like brain, liver and kidneys
2. Mental depression and confusion
3. Renal failure
4. Coma.

OVERHYDRATION OR WATER INTOXICATION

Definition

Overhydration, hyperhydration, water excess or water intoxication is defined as the condition in which body has too much water.

Causes

Overhydration occurs when more fluid is taken than that can be excreted. It also develops in some conditions such as heart failure, renal disorders and hypersecretion of antidiuretic hormone.

Signs and Symptoms

1. Behavioral changes
2. Drowsiness and inattentiveness
3. Nausea and vomiting
4. Sudden loss of weight followed by weakness and blurred vision
5. Anemia, acidosis, cyanosis, hemorrhage and shock
6. Muscular weakness, cramps and paralysis
7. Severe conditions of overhydration result in:

i. Delirium (extreme mental condition characterized by confused state and illusion)
ii. Seizures (sudden uncontrolled involuntary muscular contractions)
iii. Coma (profound state of unconsciousness in which the person fails to respond to external stimuli and cannot perform voluntary actions).

Edema: Excess Fluid in the Tissues

Edema refers to the presence of excess fluid in the body tissues. In most instances, edema occurs mainly in the extracellular fluid compartment, but it can involve intracellular fluid as well.

Intracellular Edema

Two conditions are especially prone to cause intracellular swelling:
(1) depression of the metabolic systems of the tissues, and
(2) lack of adequate nutrition to the cells. For example, when blood flow to a tissue is decreased, the delivery of oxygen and nutrients is reduced. If the blood flow becomes too low to maintain normal tissue metabolism, the cell membrane ionic pumps become depressed. When this occurs, sodium ions that normally leak into the interior of the cell can no longer be pumped out of the cells, and the excess sodium ions inside the cells cause osmosis of water into the cells. Sometimes this can increase intracellular volume of a tissue area—even of an entire ischemic leg, for example—to two to three times normal. When this occurs, it is usually a prelude to death of the tissue. Intracellular edema can also occur in inflamed tissues. Inflammation usually has a direct effect on the cell membranes to increase their permeability, allowing sodium and other ions to diffuse into the interior of the cell, with subsequent osmosis of water into the cells.

Extracellular Edema

Extracellular fluid edema occurs when there is excess fluid accumulation in the extracellular spaces. There are two general causes of extracellular edema:
(1) Abnormal leakage of fluid from the plasma to the interstitial spaces across the capillaries, and

(2) Failure of the lymphatic to return fluid from the interstitial back into the blood. The most common clinical cause of interstitial fluid accumulation is excessive capillary fluid filtration.