UNIT 6 WATER

Structure

6.1 INTRODUCTION

Units 3, 4 and 5 in this course covered the macronutrients. Macronutrients, you know, are those nutrients which are required in large amounts by our body namely, carbohydrates, fats and proteins. We studied about their functions, role and food sources. Other than the macronutrients, we do require certain other nutrients, some of which are required in very small amounts, but these are extremely important. We shall learn about these nutrients, i.e. the micronutrients in the next few units. Now in this unit, we shall focus on water, the most important nutrient of all the essential nutrients required by the body.

The absence of water affects us more quickly than the absence of any other nutrient. Meeting our need for a continuous supply of life-sustaining water and maintaining the body water in different compartments are major nutritional and physiologic tasks. What is the role of water in the body'? How is the water distributed and held in the body? What is meant by water balance'? What is our water requirement'? What do the disturbances in fluid balance lead to? You will find a detailed discussion on these important aspects in this unit.

Objectives

After studying this unit, you will be able to:

- enumerate the functions of water in the human body,
- discuss the factors influencing water content of the human body,
- explore the most basic nutrition task of water balance and, the mechanisms involved in regulating this,
- appreciate the requirements of water for different age groups,
- explain the disturbances in fluid balance and consequences, and
- describe the importance of averting fluid imbalance and methods of correcting fluid imbalance when it occurs.

6.2 WATER: AN ESSENTIAL BUT OVERLOOKED NUTRIENT

You may already know that the total body water (TBW) constitutes 50-60% of the body weight. A 70 kg 'standard male' contains 42 litre water – 60% of his body weight while an adult female contains 55% of body weight as water. Why is there a difference in TBW content between males and females? This decrease is due to a higher fat content found in females. The proportion of water in the body, however, varies in individuals depending on body composition. Let us see how.

For example, you will find that muscular people have a higher proportion of water than the less muscular or obese people. Can you say why? Well, simply because the striated muscle contains more water than any other body tissue (except blood). While water content of the muscles is 65-75%, it amounts to less than 25% of the weight of fat. Consequently, the differences in body water between individuals are largely due to the variations in body composition i.e. differences in lean tissues vs. fat. Similarly, males have a higher proportion of water in their bodies than do females because they have a higher proportion of lean tissue and a lower proportion of fat. An athlete will have a greater proportion of body water than a non-athlete as he/she has developed a relatively larger proportion of lean body mass. You would notice that there is a steady fall in the proportion of water as we age, which is due to an increased deposition of fat in the body, as well as, loss of muscle mass with age. Table 6.1 presents the percentage of total body water at different stages of lifecycle.

Table 6.1: Percentage of TBW in infants, children and adult

Subjects	Total Body Water (%)
Infants and children	
At Birth	75
At 1 year	58
6 - 7 years	62
Males	
16 - 30 years	58.9
31 - 60 years	54.7
61 - 90 years	51.8
Females	
16 - 30 years	50.9
31 - 90 years	45.2

Source: Guthrie H A, and Picciano M E (1995).

So what makes water the most essential of all the essential nutrients? The discussion below highlights the role of water in the body.

6.2.1 Functions of Water in the Body

Because of its unique chemical and physical characteristics, water plays several key roles in our life processes. These functions are described herewith:

- *Water as a medium and solvent:* Water is the medium of all cell fluids, including digestive juices, lymph, blood, urine, and perspiration. All the physiochemical reactions that occur in the cells of the body take place in the precisely regulated environment of the body fluids. Water enters into many essential reactions, such as hydrolysis, that occurs in digestion. Water is an end-product in the oxidation of energy-yielding nutrients.

Water is a solvent for the products of digestion, holding them in solution and permitting them to pass through the absorbing walls of the intestinal tract into the blood stream. Due to its ability to dissolve the nutrients and cellular waste products, it carries nutrients to the cells and removes the waste products to the lungs, kidneys, gut and skin.

- *Water as a lubricant:* All fluids have lubricating properties as they can make it easier for the solid materials to slip over one another. Water-based fluids act as lubricants in various parts of the body, most notably within joints where synovial fluid makes movements easier and minimizes wear and tear in cartilage and bone. The lubricant action of saliva and mucus in the mouth and the oesophagus is not so obvious.

- *Water as a temperature regulator:* Water plays an important role in the distribution of heat throughout the body and the regulation of body temperature. Heat is generated in the body due to hard work, exposure to heat, fever or merely by the metabolism of energy-yielding nutrients. The most effective route of heat loss from the body is via the evaporation of water as perspiration from the surface of the skin. When perspiration evaporates, the heat is largely drawn from the body. Under normal circumstances, the body is continuously cooled by the evaporation of perspiration from the surface of the skin, known as *insensible perspiration.*

- *Water as a source of dietary minerals*: Allhough water is coinposed of only oxygen and hydrogen, the water we drink or use in food preparation can contain significant amounts of minerals, such as calcium, magnesium, zinc, copper and fluoride; the amount will vary based on the source of water and any treatment the water has been put through. While hard water will contain magnesium and calcium, the soft water may contain sodium.

  Being an effective solvent, water may carry significant amounts of toxic compounds of lead or cadmium, pesticides and also industrial waste products. Regular monitoring of water supply to check for such contamination is essential to safeguard the public health.

The discussion above highlights the significance of water. Within the body, the water is held in the compartments. What are these compartments? What are the forces that control the water distribution in the body? Read the next section to understand these concepts.

6.3 WATER DISTRIBUTION AND COMPARTMENTS OF BODY WATER

Each one of us has a ve itable 'sea within', held in place by multiple membranes and our protective envelope of skin. Within this envelope, water diffuses freely to all parts and is controlled by its own chemical potential. There are various compartments of fluid in our body, separated by membranes. The quantity of water contained in every compartment is beautifully balanced by the forces that maintain equilibrium among the parts. There are electrolytes and other solutes in the water, the concentration and distribution of which determine internal shifts and balances in the body water. All these aspects, including the water distribution in the body are described in **this** section. We begin by getting to know the body water compartments.

6.3.1 Compartments of Body Water

Within the body, water is found in two major compartments. These are: .

- The intracellular compartment (inside the cell)
- The extracellular compartment (outside the cell).

The water containing varied concentrations of biochemicals in these compartments is, therefore, referred to as *intracellular fluid* (*ICF*) and *extracellular fluid (ECF)*. Intracellular fluid compartment constitutes two-thirds of the total body water, as illustrated in Figure 6.1.

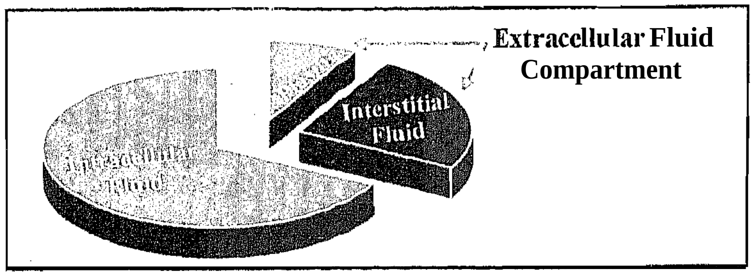

Figure 6.1: Intracellular fluid compartment: two-thirds of the total body water

Figure 6.2 diagramatically represents the two fluid compartments of the body.

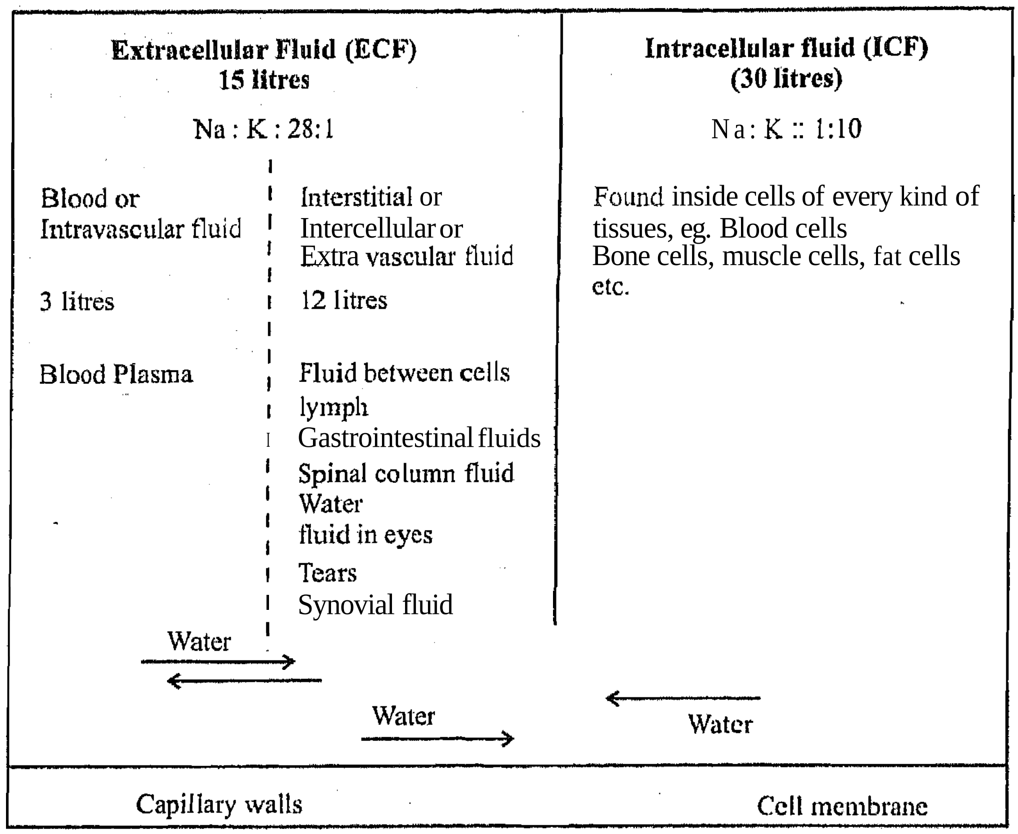

Figure 6.2: The two major fluid compartments of the body

The chemical composition of these fluid compartments varies from place to place in the body, depending on the type of cells the fluid within and around it. The intracellular and extracellular fluid compartments are separated by the semi-permeable membranes of the body's cells. These membranes allow water to pass through them but form a selective barrier to other chemicals, allowing them to diffuse or to be carried readily and restricting the passage of many others. Let us learn about ICF and ECF in more details.

A) *The intracellular fluid* or the water within the cells makes up about 40-45% of the total body weight. Because the body cells are the sites of vast metabolic activity, it is of no surprise that the total water inside the body cells is about twice the amount outside the cells. These are high in potassium and magnesium and low in sodium and chloride ions.

B) The *extracellular fluid* compartment is further subdivided into several smaller compartments as you may have noticed in Figure 6.2. These include:

- Plasma
- The intravascular fluid compartment, and
- The intercellular [interstitial or extravascular fluid (ISF)] compartment.
- The transcellular fluid compartment

Let us get to know a little more about these compartments.

Plasma is the only major fluid compartment that exists as real collection of fluid all in one location. It differs from ISF in its much higher protein content. Blood contains suspended red and white cells so plasma has been callecl the *interstitial fluid of the blood.* The fluid compartment called the blood volume is interesting in that it is a composite compartment containing ECF and ICE

The extracellular fluid compartment is sub-divided into the *intravascular fluid compartment* (fluid within the blood vessel) and *intercellular/interstitial/ extravascular fluid compartment* (fluid between the body cells but outside of the blood vessel).

The *intravascular fluid* comprises of all the fluid within the blood vessels of the "vascular" system – namely, the arteries, veins and capillaries. The *intercellular compartment,* on the other hand, contains the fluid around and between the cells of the body, which carries nutrients to the cells and collects waste products for eventual excretion.

The intravascular fluid is separated from the intercellular fluid by the walls of the blood vessels, which also form a semipermeable barrier that allows the water to pass through it but exerts a strict selective control over the passage of other chemicals.

The *transcellular fluid* is *a* small compartment that represents all those body fluids which are formed from the transport activities of cell. These do not readily exchange water with the bulk of the extracellular compartment and includes cerebrospinal fluid and secretions of the gastrointestinal tract.

The fluids in the eyeball (vitreous humor), around joints (synovial fluid), and within the digestive tract, as well as, a few specialized fluids are outside the cells and thus are exrtracellular, but do not readily exchange water with the bulk of the extracellular compartment. These fluids are called *transcellular fluid compartment.*

So we have looked at the various water compartments of our body. How is water distribution controlled in these compartments'? The next sub-section focuses on this aspect.

6.3.2 Forces Influencing Water Distribution

Two major types of solute particles control body water distribution by their varying concentrations in body fluids and the forces these concentrations create. These solute particles are of two kinds – *electrolytes,* that include the positively charged *sodium* and *potassium inns* and the *negatively charged chloride ions,* commonly known as *electrolytes* and the *plasma protein.* The concentration of sodium inside the cells is about 5 mEq/L (miliequivalents) compared with 140 mEq/L outside while for chloride ions, concentration is 96-106 mEq/L. The normal range for potassium is 3.7 to 5.2 mEg/L. The specific electrolytes and the plasma proteins are, therefore, the main players in the balancing act in our "sea within".

The movement of water is controlled mainly by osmotic pressure generated by the inorganic ions in solution in the body. Osmotic pressure is directly proportional to the number of particles in solution and usually refers *to the pressure exereted by water or solvents flowing into a solution at the cell membrane.* The osmotic pressure of the intracellular fluid, is the function of its content of potassium, the predominant cation in the intracellular fluid, as illustrated in Figure 6.3. By contrast, the osmotic pressure of extracellular fluid may be considered relative to its content of sodium, the major cation present in extracellular fluid. Although variations in the distribution of sodium and potassium ions are the principal causes of water shifts between the various compartments, chloride and phosphate ions also influence the water balance.

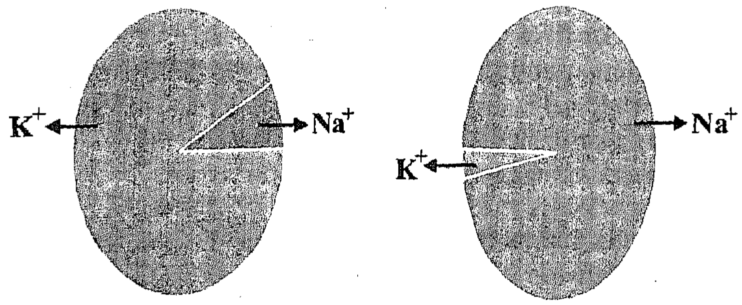

Figure 6.3: Relative levels of Na^+ and K^+ in the intracellular and extracellular fluid

The plasma proteins, which are non-diffusible because of their large molecular weight, also play an important role in maintaining osmotic equilibrium. Oncotic pressure, or what is also known as *Colloidal Osmotic Pressure (COP),* is *the pressure at the capillary membrane cuused **by** dissolved proteins in the plasma.* Oncotic pressure helps to retain water within the blood vessels, thus maintaining the integrity of the blood volume in the vascular compartment.

With the understanding of water distribution and the forces which come in play, let us next study the concept of water balance. But before that, let us review what we have learnt so far.

Check Your Progress Exercise 1

1) What proportion of TBW constitutes in our body weight? What are the factor(s) influencing it?

....

....

....

2) Enlist the functions of water in the body. Also discuss how water helps in regulating body temperature.

....

....

....

....

3) Define the following terms:

a) Intracellular fluid'

....

....

b) Transcellularfluid

....

....

....

c) Osmotic Pressure

....

....

....

4) State whether the following statements are true or false. Correct the false statement.

- Water content of extracellular fluid is more than that of ICF.
- TBW increases with age.
- Water content: of ECF is more than that of ICF.
- Intercellular fluid is a component of intracellular fluid.
- Oncotic pressure helps in maintaining the integ ity of the blood volume.

5) Fill in the blanks:

i) ....is the predominant electrolyte in the ECF and ....in the ICF.

ii) Intercellular fluid is also known as .... fluid.

iii) .... is an example of transcellular fluid.

iv) Synovial fluid bathes the ....and serves as a .... fluid.

v) The extracellular fluid is made up of ....fluid and .... fluid.

6.4 WATER BALANCE

The amount of fluid in the body is tightly controlled because imbalance can be devastating. In a normal individual, the maintenance of water balance is achieved by adjusting both water intake and excretion as needed. What are the major sources of water intake and excretion? Read further to find out.

6.4.1 Water Intake

The,major sources of water are:

1) The preformed water that we consume as water or as beverage. This will include both preformed water in fluids and in foods.

   The amount of *fluids that we consume as beverages, including water* depends on climatic conditions and habit. People living in tropics, where there are greater losses of water due to evaporation from the skin, consume more water than do those in temperate climates, and people who engage in strenuous physical activity drink more than do people leading a sedentary lifestyle. This may amount to as much as 1-2 L/ day. This may also be referred to as ***preformed*** *water* in *fluids*.

   Foods (other than water and beverages) are the second most important sources of water for the body. Most foods contain 50% water, but **milk** has the highest amount of water. Fruits and vegetables rank next to milk, while fats and oils do not contain any water, The water contained in cookies, cakes and chocolates are relatively low. This entire group contributes to 25-30% of daily water intake. This may also be referred to as *preformed water* in *foods.*

2) Water that arises from oxidation of foods within the body, which is referred to as *water of oxidation* or *metabolic water*. Water which comes from the oxidation of food is the last source of water. 1 g of starch yields 0.6 g of water; 1 g of protein 0.41g; and 1 g of fat gives 1.07 g of water. This source contributes only about 10% of the total water input. This is also known as *water of oxidation / metabolic water.* The water embedded in the network of glycogen molecules in muscle and liver is made available to the body when it is used as a source of energy. Therefore, in case of athletes using glycogen reserves as a source of energy during intense physical activity, this serves as an additional source of water.

Next, what are the routes of water loss from our body? Let us find out.

6.4.2 Water Output (Losses of body water)

Water is lost from the body by the four routes, namely kidneys (renal system), skin, lungs and intestine. Let us discuss each of these routes.

A) *Renal loss:* Normal adult kidneys excrete about 1-2 liters of urine daily. The water in this total volume is made up of two portions: *obligatory* and *facultative.*

i) *Obligatory water excretion*: The kidney is 'obligated' to excrete some water to rid the body of its daily load of urinary solutes; the body's excretory system is designed to maintain the necessary balance through its filtering and selective reabsorbing system in the kidneys. About 15 ml of water is required to dissolve 1 g of solute materials arising out of the metabolism. The quantity of obligatory water excretion depends on the load on the metabolic products – chiefly urea and sodium chloride. The average adult obligatory water excretion is about 900 ml.

ii) *Facultative water excretion*: In addition to obligatory water loss, an additional 500 ml, more or less water is excreted for maintaining water balance.

B) Skin: The water loss from the skin is through perspiration, which could be insensible and/or visible.

i) *Insensible perspiration* accounts for *a* relatively constant amount of water loss that is proportional to the surface area of the body. It is so called because the evaporation takes place from the skin immediately and the water loss is not noticeable. As we have already seen, this evaporation is an important means by which body temperature is maintained. Infants have a much greater surface area relative to body weight than do adults; consequently, they are much more vulnerable to water loss from the skin and rapid changes in body temperature.

ii) The water losses by *visible perspiration* are highly variable; the amount could be as high as 4L in hot climate or during strenuous physical activity. Whenever a great deal of water is lost by perspiration, body water is conserved by the elimination of much more concentrated urine.

C) *Intestine:* A small quantity of water (about 100-200 ml) is normally lost in faeces, but this can exceed 5 L in diarrhoea1 episodes.

D) *Lungs:* The air expired from the lungs also contains water. Any condition that would increase the rate of respiration – for example, fever-increases the water Ioss by this route. An individual engaged in the vigorous activity will loose more water by this route as compared to one who is sedentary. The details of input and output in a cool environment are shown in Table 6.2.

Table 6.2: Daily water balance in man

Source	Input (ml)	Source	Output (ml)
Food	800 - 1000	Insensible loss	800 - 1000
Oxidation of Food	300 - 400	Sweat	200
as water	1000 - 2000	Faeces	100 - 200
		Urine	1000 - 2000
Total	2100 - 3400		2100 - 3400

Source: West J B. (1990).

Now, we have a good idea about the water intake and output. It is interesting to note that, inspite of the water output, the total body water is maintained. How is the water balance maintained in the body? Let's learn about this concept next.

6.4.3 Regulation of Water Balance

The input of water, as well as, its loss can be highly variable due to individual habits and environmental factors; in spite of this, the total body water needs to be maintained constant to achieve normal osmolality for physiological functions. The *osmolality* is a measure of the osmoles of solute per kilogram of solvent. In chemistry, the *osmole* (*Osm*) is a unit of measurement that defines the number of moles of a chemical compound that contribute to a solution's osmotic pressure.

Although the sources of water to the body and the loss of water from the body are in balance, the fluid exchanges that take place in a 24 hour period are of tremendous magnitude and impressive in precision and regulation. Regulatory steps operate which control water input by thirst and urinary output by kidneys. This regulation of water balance by digestive system, kidneys, hormonal control and thirst is discussed herewith.

A) For the ***digestive*** process alone, the estimated daily volume of fluid that enters and leaves the gastrointestinal (GI) tract is estimated to be about 9 litres (consisting of saliva, gastric juice, bile, pancreatic and intestinal juice and water intake). The fluid exchange between the GI tract and the blood circulation are variable from hour to hour; yet they are so balanced that the volume of blood and the fluids within the tract are in equilibrium. The daily losses from the bowel are only around 100-200 ml. Almost all of the fluid is reabsorbed from the gut.

B) ***The kidneys*** are highly efficient conservators of body water. Although the kidneys filter 180 L of blood per day (125 ml / min), the urinary output is in the range of 1-2 L for 24 hours. Before the urine leaves the kidneys, variable amount of water and various solutes are reabsorbed by the renal tubules.

   This ability plays a major role in maintaining blood volume within normal limits. The eventual urine produced after reabsorption has occurred, is collected in the bladder and excreted periodically,

C) Hormonal control *of fluid* balance: When water intake is insufficient or water loss is excessive, the kidneys compensate by conserving water and excreting more concentrated urine. The renal tubules increase water reabsorption in response to the hormonal action of ADH (anti-diuretic hormone) released by the pituitary glands under the stimulation of the hypothalamus, and this helps to restore the blood volume. Water balance is critical in maintaining the blood volume, which in turn influences blood pressure.

Cells in the kidneys respond to low blood pressure by releasing an enzyme called *renin*, which in turn causes the kidneys to reabsorb sodium through a series of events. Sodium reabsorption in turn is accompanied by water retention thus helping to restore blood volume and the blood pressure.

Renin activates a protein called *angiotensinogen* in the blood to its active form, *angiotensin*. Being a powerful vasoconstrictor, angiotensin nasrows the blood vessel, thereby raising the blood pressure. Angiotensin also mediates the release of the hormone aldosterone, which causes the kidneys to retain more sodium and thus the water. Again, the effect is that when more water is needed, less is excreted.

In summary, the following three mechanisms effectively restore homeostasis by responding to low blood volume or highly concentrated blood, as illustrated' in Figure 6.4.

* ADH causes water retention.
* Angiotensin constricts blood vessels.
* Aldosterone causes sodium retention.

These mechanisms cannot maintain water balance by themselves. However, they work only if a person drinks enough water. Homeostasis, as you may already know, is the process whereby the internal environment of an organism tends to remain balanced and stable. Homeostasis as a mechanism is discussed in detail in the Human Physiology Course, in Unit 8. Do go through the unit carefully.

Kidneys.retain sodium and water, thus increasing blood volume.

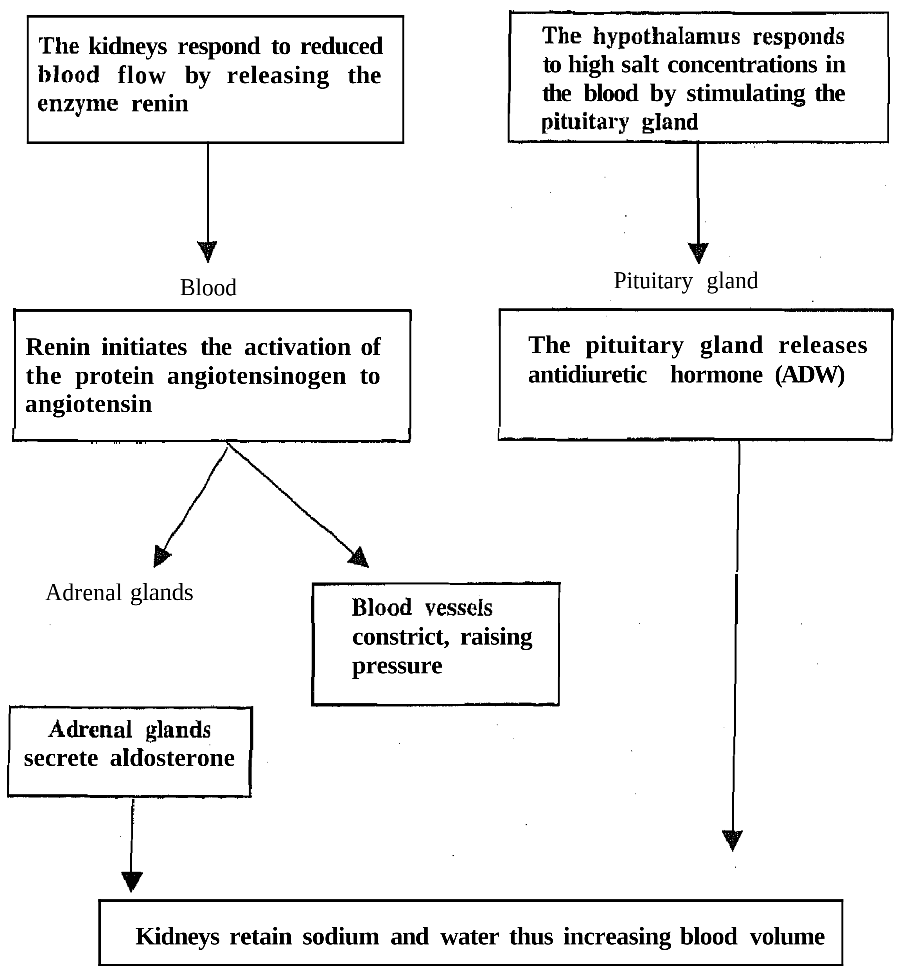

Figure 6.4: How the body regulates water excretion

Source: Whitney et.al. (1998).

D) *Thirst and satiety* influence water intake, apparently in response to changes sensed by the mouth, hypothalamus and nerves. When the blood is too concentrated (having lost water, but not the dissolved substances within it), the mouth becomes dry, and the person responds by drinking .When the hypothalamus detects that the blood is too concentrated, it also initiates the drinking behaviour. Besides stimulating the thirst sensation, the hypothalamus stimulates the pituitary gland to release ADH. This hormone increases the reabsorption of water.

Thirst drives a person to seek water, but it often lags behind the body's needs. A water deficiency that develops slowly can switch on the drinking behaviour in time to prevent dehydration, but a deficiency that develops quickly may not. Also, thirst itself may not always remedy a water deficiency; a person must notice the thirst signal, pay attention, and take time to get a drink. The long distance runner, the gardener in hot weather, the child busy playing, and the elderly person whose thirst sensation may be blunted can experience serious dehydration if they fail to drink promptly in response to their need for water. So then how much water does the body need? Let us find out. But after the check your progress exercise.

Check Your Progress Exercise 2

1) Why is it essential to maintain water balance in the body? How is it done?

....

....

....

....

....

2) Enlist the major sources of water.

....

....

....

....

....

3) What are the routes by which our body looses water? Briefly discuss any one of these.

....

....

....

....

....

4) What is the role of the following in regulating water balance?

a) Kidneys: ....

....

....

b) Hormones : ....

....

....

6.5 REQUIREMENTS FOR WATER

The body has no provision for water storage; therefore the amount of water lost every 24 hours must be replaced to maintain health and body efficiency. The precise need for water depends on a person's body weight and lifestyle. The requirements in relation to body weight varies in a general way with age; the younger the individual, the greater his/her requirements for water per unit body weight. Under ordinary circumstances, a reasonable allowance based on recommended energy intake is 1.0 ml / Kcal for adults and 1.5 ml / Kcal for infants. This translates into:

- 35 ml / kg in adults
- 50 - 60 ml / kg in children
- 150 ml / kg in infants

Infants have an increased need for water because of the limited capacity of their kidneys to handle the renal solute load, their higher pe centage of body water and large surface area per unit of body weight. Exercise, high temperature, low humidity, high altitude and a high fibre diet increase fluid needs. Alcoholic beverages and those containing caffeine such as coffee, tea and sodas, however, are not good substitutes for water; both alcohol and caffeine act as diuretics, causing the body to lose fluids.

What are the consequences of disturbances in fluid balance? We assume you know! Read the next section and refresh your memory.

6.6 DISTURBANCES IN FLUID BALANCE

The correct functioning of cells and tissues depends on appropriate concentrations of nutrients; so any *abnormal loss* or *accumulation of jluid* can cause a variety of problems. These problems may be caused by:

a) water loss from diarrhoea, nausea, excessive perspiration, or fever, resulting in dehydration, and

b) undesirable changes in the distribution of fluid within the body.

Let us learn about these problems in more details. r

6.6.1 Dehydration

Dehydration is defined *as the excessive loss of body water*. It may occur because of inadequate intake, or abnormal loss of body water or a coinbination of both. The fall in the level of body water associated with dehydration is associated with a fall in blood volume with a consequent fall in blood pressure. The symptoms of dehydration are:

- Thirst
- Loss of appetite
- Decreased urination
- Impaired physical performance
- Nausea
- Impaired temperature regulation
- Muscle spasms
- Increased pulse rate
- Increased respiration rate
- General debilitation

Symptoms of severe dehydration appear when fluid .levels fall by more than 10%, whereas a 20% reduction is fatal. With water loss in excess of 10% of body weight, there is a possibility of cardiovascular failure caused by a reduction in blood pressure and a compensating increase in the heart rate as highlighted earlier in Figure 6.2.

Abnormal loss of water occurs from prolonged vomiting, haemorrhage, diarrhoea, protracted fevers, burns, excessive perspiration, drainage from wounds, and so on.

Athletes loose considerable amounts of water through the skin as a result of their strenuous physical activity.

People for whom water losses may be accompanied by significant losses of sodium include those engaged in strenuous physical activity of any sort, those exposed to high environmental temperatures at work, and visitors to tropical regions who are unaccustomed to heat. Such people, and in general anyone loosing in excess may need small amounts of salt along with the fluid they drink to make up their sodium loss. The Indian tradition of serving mildly salted watery buttermilk, panna, salted lime juice on a hot afternoon are all examples of replenishing the fluid and salt loss through skin. Children who are ill, especially those with fever, diarrhoea, and increased perspiration, need to be reminded to drink plenty of fluid. One other situation that demands extra fluid for the body is a long airplane flight; a traveler can lose approximately 1.5 litres of water during a 3-hour flight chiefly due to increased in sensible perspiration. The dehumidified air in the airplane is so dry that excessive 'insensible' perspiration and evaporation occur.

Athletes in good physical condition experience a reduction in athletic performance if they lose 3% of body water. Studies investigating the factors limiting our efficiency at work suggest that a lack of adequate water intake has a much more significant effect than does a lack of food. Reduction of as little as 2% of total body water causes a decline of 20 to 30% in efficiency at work.

During starvation or a high-protein and low- carbohydrate diet, excessive loss of body water, sodium, potassium is lost in the urine. This accounts for the rapid initial weight loss and weakness often reported by people on starvation-like diets.

The discussion above focused on dehydration, the condition when the water output is more resulting in imbalance. Opposite to this condition, when intake of fluid is greater, the condition caused is called *oedema*. Let us get to know about this condition.

6.6.2 Oedema

In some pathological conditions the body is in a positive water balance; that is the intake of fluids is greater than the excretion, and the patient is said to have oedema. *Oedema results when the body **water-** is increased to the levels of 10% or **more** above normal.* We had learnt in the earlier section that plasma proteins exert oncotic pressure that helps to retain water within blood vessels, thus preventing its leakage from plasma into the interstitial spaces. In certain disease states as in Kwashiorkor, the protein content of the plasma is exceptionally low, water leaks into the interstitial spaces causing oedema. Oedema is one of the classical symptoms of kwashiorkor, and this has already been covered in the unit on Proteins. Dietary treatment with proteins of high biological value should be initiated to correct this.

In contrast to the oedema arising due to a dietary protein deficiency in PEM, the oedema noticed in Nephrotic syndrome results due to an increased permeability of the glomerular capillary; the plasma proteins, which are normally retained in the blood, escape into the urine causing proteinuria. With a loss of plasma proteins in the urine, blood proteins fall sharply, giving rise to oedema.

Congestive cardiac failure (CCF) and cirrhosis of the liver are examples of conditions with a disturbance in sodium excretion, namely sodium excretion is reduced thereby contributing to the retention of water. Treatment will involve restriction in the amount of salt with / without fluid restriction in the diet. At times, diuretics may be used to facilitate fluid excretion.

Fluid loss secondary to diarrhoea has been responsible for thousands of deaths of children in developing countries. Oral rehydration therapy (ORT) with a simple mixture of water, salts and sugar has been highly effective in reducing the number of deaths.

No wonder water has been appropriately described as the most forgotten and taken-for-granted nutrient.

Check Your Progress Exercise 3

1) What are the factors which influence the water requirements? Also state the water allowance for a 12-year old.

....

....

....

....

2) Why infants needs for fluid is more as compared to adults.

....

....

....

....

3) What factors are responsible for increasing fluid needs? Why alcoholic beverages are not considered as good substitutes for water?

....

....

....

....

4) Discuss the factors responsible for disturbances in fluid balance.

....

....

....

....

5) Elicit the role of proteins in giving rise to oedema.

....

....

....

....

6.7 LET US SUM UP

In this unit, we learnt that water inspite of being ignored, is an essential nutrient required for life. Though the content of total body water varies from individual to individual, it plays a key role in the body. You would recall that these involve carrying several nutrients and waste products throughout the body, serves as the solvent for minerals, vitamins, amino acids, glucose and a multitude of other small molecules, and acts as lubricant and cushion around joints, aids in body's temperature regulation, serves as a shock absorber inside the eyes, spinal cord and in pregnancy, the amniotic sac surrounding the foetus in the womb and actively participates in many chemical reactions.

Then we saw that water is a constituent of every cell of the body intracellular fluid. spaces between cells (interstitial space), and also within the blood (intravascular fluid). Water, is obtained from various sources such as beverages, solid foods and energy-yielding nutrients within the body. On the other hand, water is eliminated from the body through urine, skin, lungs and faeces.

We, then, learnt about a variety of sensitive physiological control systems. Finally, we came to know that in order to be adequately hydrated, the average adult should consume about two litres of fluid per day, in the form of clean water and in addition consume non-caffeinated, non-alcoholic beverages, soups, milk, butterinilk, and other beverages. The disturbances in fluid balance, is of two types: dehydration and oedema.

6.8 GLOSSARY

Biological value : a measure of protein quality determined by comparing the amount of nitrogen retained in the body with the arnount absorbed frorn diet.

Cirrhosis : a serious liver condition characterized by irreversible scarring of the liver that can lead to liver failure and death. Scarring results in loss of liver cells and impairs liver function.

Congestive Cardiac Failure : the inability of the heart to pump blood effectively to the body or requiring elevated filling pressures in order to pump effectively.

Dehydration : depletion of body fluids.

Diuretics : a substance or drug that tends to increase the urine discharge.

Insensible perspiration: water given off by the intact skin as vapour by simple evaporation from the epidermis or as sweat.

Kwashiorkor : severe malnutrition caused by a lack of proteins especially in young children.

Lean Body Mass : everything in the body except for fat, including bone, organs, skin, nails and all body tissues including muscles.

Nephrotic syndrome : a condition characterized by high levels of protein in the urine, low levels of protein in blood, tissue swelling and high cholesterol.

Oedema : swelling of the extremity due to excessive accumulation of serous fluid in tissue.

Oncotic pressure : also known as colloidal osmotic pressure; the pressure at the capillary membrane caused by dissolved protein molecules in the plasma.

Osmolality : the concentration of an osmotic solution, usually expressed in terms of osmoles.

Osmotic pressure : the pressure exerted by water or other solvents flowing into a solution through a membrane.

Striated muscle : a muscle-tissue that is connected at either or. both ends to a bone and moves parts of the skeleton.

Synovial fluid : a clear, sticky fluid that is released by membrane lining joints and tendon sheaths and acts of lubricant.

Vitreous humor : the colourless mass of gel that lies behind the transparent, lens and in front of retina and fills the center of eyeball.

6.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) TBW constitutes 50-60% of the body weight. The varying body composition and age influences TBW.

2) Water acts as a medium and solvent, a lubricant, temperature regulator and source of dietary minerals.

   Water plays an important role in the distribution of heat throughout the body and the regulation of body temperature. Heat is generated in the body due to hard work, exposure to heat, fever or merely by the metabolism of energy-yielding nutrients. The most effective route of heat loss from the body is via the evaporation of water as perspiration from the surface of the skin. When perspiration evaporates, the heat is largely drawn from the body.

3) a) The intracellular fluid is the water within the cells which makes up about 40-45% of the total body weight.

   b) The transcellular fluid is a small compartment that represents all those body fluids which are formed from the transport activities of cell.

   c) Osmotic pressure refers to the pressure exerted by water or solvents flowing into a solution at the cell membrane.

4) *a)* True

   b) False. **A** steady decrease is seen in TBW with an increase in age.

   c) False. Water content of ECF is less than that of ICF.

   d) False. Intercellular fluid is a component of extracellular fluid.

   e) True.

5) i) Na, K

   ii) Interstitial or extravascular

   iii) Synovial fluid

   iv) Joints, transcellular

   v) Intravascular, intercellular.

Check Your Progress Exercise 2

1) The amount of fluid in the body is tightly controlled because imbalance can be devastating. In a normal individual the maintenance of water balance is achieved by adjusting both water intake and excretion as needed.

2) The major sources of water are (a) the performed water that we consume as water or as a beverage, and b) water that arises from oxidation of foods within the body which is referred to as water of oxidation or metabolic water.

3) Water is lost from the body by the four routes, namely kidneys, (renal system) skin, lungs and intestine. Discuss any one of these on your own based on your understanding of the topic.

4) a) When water intake is insufficient or water loss is excessive, the kidneys compensate by conserving water and excreting more concentrated urine. The renal tubules increase water reabsorption in response to the hormonal action of ADH (anti-diuretic hormone) and this helps to restore the blood volume. Water balance is critical in maintaining the blood volume, which in turn influences blood pressure. Cells in the kidneys respond to low blood pressure by releasing an enzyme called renin, which in turn causes the kidneys to reabsorb sodium through a series of events. Sodium reabsorption in turn is accompanied by water relention thus helping to restore blood volume and the blood pressure.

b) Renin activates a protein called angiotensinogen in the blood to its active form, angiotensin. Being a powerful vasoconstrictor, angiotensin narrows the blood vessel, thereby raising the blood pressure. Angiotensin also mediates the release of the hormone aldosterone, which causes the kidneys to retain more sodium and thus the water. Again, the effect is that when more water is needed, less is excreted.

***Check* Your Progress Exercise 3**

1) The water requirements depend on a person's body weight, age and lifestyle. 50-60 ml /kg.

2) Infants have an increased need for water because of the limited capacity of their kidneys to handle the renal solute load, their higher percentage of body water and large surface area per unit of body weight.

3) Exercise, high temperature, low humidity, high altitude and a high fibre diet increase fluid needs. Alcoholic beverages and those containing caffeine such as coffee, tea and sodas, however, are not good substitutes for water; both alcohol and caffeine act as diuretics, causing the body to loose fluids.

4) Water loss from diarrhoea, nausea, excessive perspiration, or fever, resulting in dehydration, and undesirable changes in the distribution of fluid within the body.

5) In certain disease states as in Kwashiorkor, the protein content of the plasma is exceptionally low, water leaks into the interstitial spaces causing oedeina. In nephrotic syndrome, with a loss of plasma proteins in the urine, blood proteins fall sharply, giving rise to oedema.