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PG AND RESEARCH DEPARTMENT OF FOODS AND NUTRITION

CLASS : II B.Sc NUTRITION, FSM & DIETETICS

SUBJECT CODE : FNU41

SUBJECT NAME : HUMAN NUTRITION

SYLLABUS

UNIT - I

Basic concepts of Nutrient, Carbohydrates - Definition, Sources, requirements, Digestion and absorption and metabolism. Dietary fibre definition, types-soluble and insoluble fibre, sources of fibre, physiological effects of dietary fibre, role of fibre in human nutrition, requirements. Water - functions, water compartment, regulation,water balance, and disorders of water balance.

BASIC CONCEPT OF NUTRIENT

“Nutrients are the compounds in food that provide us with energy that facilitates repair and growth and helps to carry out different life processes.”

Not all nutrients provide energy but are necessary for some form or the other. These nutrients are divided into two categories:

- Macronutrients, which are required by the body in large amounts.
- Micronutrients, which are required by the body in small amounts.

Types of Nutrients

In general, there are two types of nutrients:

- Macronutrients
- Micronutrients

Above nutrients could be obtained from the environment. Macronutrients provide energy to a living being for the function of the metabolic system. They provide massive energy and it is converted used to obtain energy. Macronutrients include carbohydrates, fats and proteins.

Micronutrient provides essential components for metabolism to be carried out. They also build and repair damaged tissues in order to control the body process. Micronutrients include calcium, iron, vitamins, minerals and vitamin C.

Macronutrients

Nutrients that are needed in large amounts are called macronutrients. There are three classes of macronutrients: carbohydrates, lipids, and proteins. These can be metabolically processed into cellular energy. The energy from macronutrients comes from their chemical bonds. This chemical energy is converted into cellular energy that is then utilized to perform work, allowing our bodies to conduct their basic functions. Water is also a macronutrient in the sense that you require a large amount of it, but unlike the other macronutrients, it does not yield calories.

A unit of measurement of food energy is the calorie. On nutrition food labels the amount given for “calories” is actually equivalent to each calorie (with a lowercase “c”) multiplied by one thousand. A kilocalorie (kcal) is synonymous with the “Calorie” (with a capital “C”) on nutrition food labels in Canada (i.e., 1000 c = 1 kcal = 1 C).

Calorie is the amount of energy in the form of heat that is required to heat one kilogram of water by one degree Celsius.

Carbohydrates

Carbohydrates are molecules composed of carbon, hydrogen, and oxygen. The major food sources of carbohydrates are grains, milk, fruits, and starchy vegetables, like potatoes. Non-starchy vegetables also contain carbohydrates, but in lesser quantities.

Carbohydrates are broadly classified into two forms based on their chemical structure: simple carbohydrates, often called simple sugars; and complex carbohydrates.

Simple carbohydrates consist of one or two basic units. Examples of simple sugars include sucrose, the type of sugar you would have in a bowl on the breakfast table, and glucose, the type of sugar that circulates in your blood.

Complex carbohydrates are long chains of simple sugars that can be unbranched or branched. During digestion, the body breaks down digestible complex carbohydrates to simple sugars, mostly glucose.

Glucose is then transported to all our cells where it is stored, used to make energy, or used to build macromolecules. Fiber is also a complex carbohydrate, but it cannot be broken down by digestive enzymes in the human intestine. As a result, it passes through the digestive tract undigested unless the bacteria that inhabit the colon or large intestine break it down.

One gram of digestible carbohydrates yields four kilocalories of energy for the cells in the body to perform work. In addition to providing energy and serving as building blocks for bigger macromolecules, carbohydrates are essential for proper functioning of the nervous system, heart, and kidneys.

In humans, the storage molecule of carbohydrates is called glycogen, and in plants, it is known as starch. Glycogen and starch are complex carbohydrates.

Lipids

Lipids are also a family of molecules composed of carbon, hydrogen, and oxygen, but unlike carbohydrates, they are insoluble in water. Lipids are found predominantly in butter, oils, meats, dairy products, nuts, and seeds, and in many processed foods.

The three main types of lipids are triglycerides (triacylglycerols), phospholipids, and sterols.

The main job of lipids is to provide or store energy. Lipids provide more energy per gram than carbohydrates (nine kilocalories per gram of lipids versus four kilocalories per gram of carbohydrates).

In addition to energy storage, lipids serve as a major component of cell membranes, surround and protect organs (in fat-storing tissues), provide insulation to aid in temperature regulation, and regulate many other functions in the body.

Proteins

Proteins are macromolecules composed of chains of subunits called amino acids. Amino acids are simple subunits composed of carbon, oxygen, hydrogen, and nitrogen. Food sources of proteins include meats, dairy products, seafood, and a variety of different plant-based foods, most notably soy.

The word protein comes from a Greek word meaning "of primary importance," which is an apt description of these macronutrients; they are also known colloquially as the "workhorses" of life. Proteins provide four kilocalories of energy per gram; however providing energy is not protein's most important function.

Proteins provide structure to bones, muscles and skin, and play a role in conducting most of the chemical reactions that take place in the body.

Scientists estimate that greater than one-hundred thousand different proteins exist within the human body. The genetic codes in DNA are basically protein recipes that determine the order in which 20 different amino acids are bound together to make thousands of specific proteins.

Water

There is one other nutrient that we must have in large quantities: water. Water does not contain carbon, but is composed of two hydrogens and one oxygen per molecule of water. More than 60 percent of the total body weight is water.

Without it, nothing could be transported in or out of the body, chemical reactions would not occur, organs would not be cushioned, and body temperature would fluctuate widely. On average, an adult consumes just over two liters of water per day from food and drink combined.

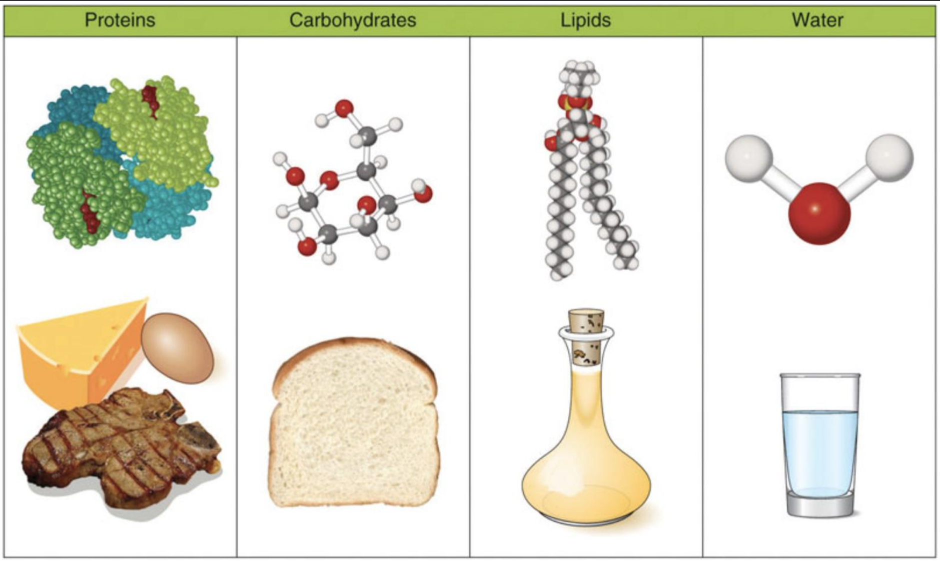

Fig 1 : Macronutrients

Micronutrients

Micronutrients are nutrients required by the body in lesser amounts, but are still essential for carrying out bodily functions. Micronutrients include all the essential minerals and vitamins. There are sixteen essential minerals and thirteen vitamins. In contrast to carbohydrates, lipids, and proteins, micronutrients are not sources of energy (calories), but they assist in the process as cofactors or components of enzymes (i.e., coenzymes). Enzymes are proteins that catalyze chemical reactions in the body and are involved in all aspects of body functions from producing energy, to digesting nutrients, to building macromolecules. Micronutrients play many essential roles in the body.

Minerals	**Major Functions**
Macro	
Sodium	Fluid balance, nerve transmission, muscle contraction
Chloride	Fluid balance, stomach acid production
Potassium	Fluid balance, nerve transmission, muscle contraction
Calcium	Bone and teeth health maintenance, nerve transmission, muscle contraction, blood clotting
Phosphorus	Bone and teeth health maintenance, acid-base balance
Magnesium	Protein production, nerve transmission, muscle contraction
Sulfur	Protein production

Trace/Micro	
Iron	Carries oxygen, assists in energy production
Zinc	Protein and DNA production, wound healing, growth, immune system function
Iodine	Thyroid hormone production, growth, metabolism
Selenium	Antioxidant
Copper	Coenzyme, iron metabolism
Manganese	Coenzyme
Fluoride	Bone and teeth health maintenance, tooth decay prevention
Chromium	Assists insulin in glucose metabolism
Molybdenum	Coenzyme

Table 1: Minerals and Their Major Functions

Minerals

Minerals are solid inorganic substances that form crystals and are classified depending on how much of them we need. Trace minerals, such as molybdenum, selenium, zinc, iron, and iodine, are only required in a few milligrams or less. Macrominerals, such as calcium, magnesium, potassium, sodium, and phosphorus, are required in hundreds of milligrams.

Many minerals are critical for enzyme function, others are used to maintain fluid balance, build bone tissue, synthesize hormones, transmit nerve impulses, contract and relax muscles, and protect against harmful free radicals in the body that can cause health problems such as cancer.

Vitamins

The thirteen vitamins are categorized as either water-soluble or fat-soluble. The water-soluble vitamins are vitamin C and all the B vitamins, which include thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folate and cobalamin. The fat-soluble vitamins are A, D, E, and K. Vitamins are required to perform many functions in the body, such as making red blood cells, synthesizing bone tissue, and playing a role in normal vision, nervous system function, and immune system function.

Vitamins	Major Functions
Water-soluble	
Thiamin (B1)	Coenzyme, energy metabolism assistance
Riboflavin (B2)	Coenzyme, energy metabolism assistance
Niacin (B3)	Coenzyme, energy metabolism assistance
Pantothenic acid (B5)	Coenzyme, energy metabolism assistance
Pyridoxine (B6)	Coenzyme, amino acid synthesis assistance
Biotin (B7)	Coenzyme, amino acid and fatty acid metabolism
Folate (B9)	Coenzyme, essential for growth
Cobalamin (B12)	Coenzyme, red blood cell synthesis
C (ascorbic acid)	Collagen synthesis, antioxidant
Fat-soluble	
A	Vision, reproduction, immune system function
D	Bone and teeth health maintenance, immune system function
E	Antioxidant, cell membrane protection
K	Bone and teeth health maintenance, blood clotting

Table 2: Vitamins and Their Major Functions

Vitamin deficiencies can cause severe health problems and even death. For example, a deficiency in niacin causes a disease called pellagra, which was more common in the early twentieth century.

The common signs and symptoms of pellagra are known as the "4D's—diarrhea, dermatitis, dementia, and death." Until scientists found out that better diets relieved the signs and symptoms of pellagra, many people with the disease ended up hospitalized in insane asylums awaiting death. Other vitamins were also found to prevent certain disorders and diseases such as scurvy (vitamin C), night blindness (vitamin A), and rickets (vitamin D).

Functions of Nutrients

The important functions of nutrients include:

- They are the main source of energy for the body.
- They help in building and repairing body tissues.
- Increases the absorption of fat-soluble vitamins.
- Helps in the synthesis of collagen.
- Provides proper structure to the blood vessels, bones and ligaments.
- They also help in maintaining the homeostasis of the body.

Protein	Necessary for tissue formation, cell reparation, and hormone and enzyme production. It is essential for building strong muscles and a healthy immune system.
Carbohydrates	Provide a ready source of energy for the body and provides structural constituents for the formation of cells.
Fat	Provides stored energy for the body, functions as structural components of cells and also as signaling molecules for proper cellular communication. It provides insulation to vital organs and works to maintain body temperature.
Vitamins	Regulate body processes and promote normal body-system functions.
Minerals	Regulate body processes, are necessary for proper cellular function, and comprise body tissue.
Water	Transports essential nutrients to all body parts, transports waste products for disposal, and aids with body temperature maintenance.

Table 3: Functions of Nutrients

CARBOHYDRATES

Definition

Carbohydates are the most abundant organic molecule in nature. They are primarily composed of the elements carbon, hydrogen and oxygen. The name carbohydrate literally means ‘hydrates of carbon’ and they are regarded as ‘Primary Energy Producers’.

They are large group of compounds commonly known as Sugars / Saccharides (Greek: Sakcharon - Sugar) or Starches, which are widely distributed in plants and animals.

Carbohydrates may be defined as polyhydroxy aldehydes or ketones having potentially active aldehydes or ketones, or they are the compounds which produce aldehydes or ketones on hydrolysis.

Sources

The most important carbohydrate found in plant is starch. It occurs in roots, tubers, leaves, vegetables and grains.

The carbohydrate found in animal is glycogen, which is abundant in liver and muscle (also termed as **animal starch**).

Glucose and fructose are simple sugars which are widely distributed in plants. Glucose is the sugar of blood and other body fluids, whereas lactose is found in milk.

Requirements

As per WHO, carbohydrate intake for everyone aged 2 years and older should mainly come from whole grains, vegetables, fruits, and pulses. Additionally, adults should consume at least 400 grams of vegetables and fruits and 25 grams of dietary fibre per day.

DIGESTION, ABSORPTION AND METABOLISM OF CARBOHYDRATES

The primary goal of carbohydrate digestion is to break down polysaccharides and disaccharides into monosaccharides that can then be converted to glucose. The major source of carbohydrates is found in plants. Glucose is the universal fuel for human cells.

The glucose concentrations in the body are maintained within limits by various metabolic processes. The principal sites of carbohydrate digestion are the mouth and small intestine. The dietary carbohydrate consists of: i. Polysaccharides: Starch, glycogen and cellulose. ii. Disaccharides: Sucrose, maltose and lactose. iii. Monosaccharides:

Mainly glucose and fructose. Monosaccharides need no digestion prior to absorption, whereas disaccharides and polysaccharides must be hydrolysed to simple sugars before their absorption.

Digestion in Mouth

Digestion of carbohydrates begins in the mouth. Salivary glands secrete α-amylase (ptyalin), which initiates the hydrolysis of a starch. During mastication, salivary α-amylase (glucose-polymer cleavage enzyme) acts briefly on dietary starch in random manner breaking some α-(1 → 4) bonds, α-amylase hydrolysis starch into dextrin’s.

Digestion in Stomach

Carbohydrate digestion halts temporarily in the stomach because the high acidity inactivates the salivary α-amylase.

Digestion in Intestine

Further digestion of carbohydrates occurs in the small intestine by pancreatic enzymes. - There are two phases of intestinal digestion. i. Digestion due to pancreatic α-amylase ii. Digestion due to intestinal enzymes: sucrase, maltase, lactase, isomaltase.

Digestion due to pancreatic α-amylase

The function of pancreatic α-amylase is to degrade dextrin’s further into a mixture of maltose, isomaltose and α-limit dextrin. The α-limit dextrin’s are smaller oligosaccharides containing 3 to 5 glucose units.

Digestion due to intestinal enzymes

Enzymes responsible for the final phase of carbohydrate digestion are located in the brush-border membrane.The end products of carbohydrate digestion are glucose, fructose and galactose which are readily absorbed through the intestinal mucosal cells into the bloodstream.

Absorption of Carbohydrates

Carbohydrates are absorbed as monosaccharides from the intestinal lumen.Two mechanisms are responsible for the absorption of monosaccharides:

i. Active transport against a concentration gradient, i.e., from a low glucose concentration to a higher concentration.

ii. Facilitate transport, with concentration gradient, i.e., from a higher concentration to a lower one.

Active Transport

A sodium dependent glucose transporter (SGLT-1) binds both glucose and Na+ at separate sites and transports them both through the plasma membrane of the intestinal cell. - The Na+ is transported down its concentration gradient (higher concentration to lower concentration) and at the same time glucose is transported against its concentration gradient. - The free energy required for this active transport is obtained from the hydrolysis of ATP linked to a sodium pump that expels Na+ from the cell in exchange of K+.

Facilitated Transport

Fructose and mannose are transported across the brush border by a Na+ independent facilitative diffusion process, requiring specific glucose transporter, GLUT-5. - The same transport can also be used by glucose and galactose if the concentration gradient is favourable. - The sodium independent transporter, GLUT-2 that facilitates transport of sugars out of the mucosal cells, thereby entering the portal circulation and being transported to the liver.

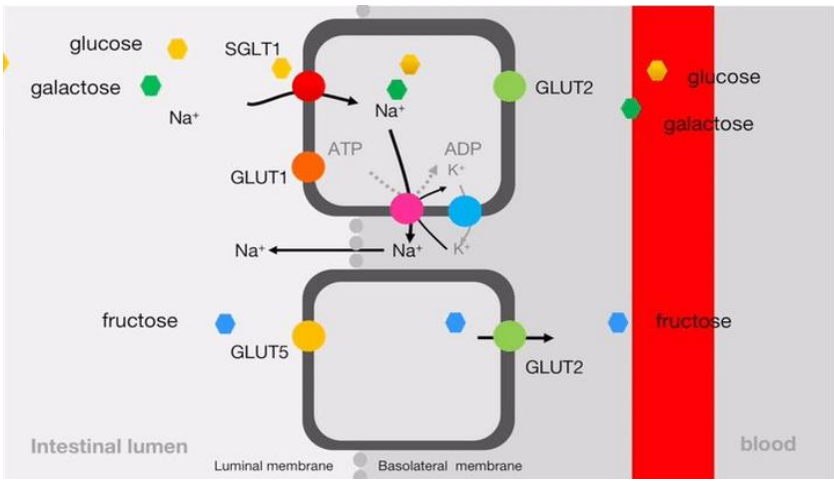

Fig 2 : Absorption of carbohydrates

Metabolism of Carbohydrates

Metabolism of carbohydrates includes the process where in complex carbohydrates with 3 or more sugar units in a chain are broken down into simple mono- and disaccharides like glucose and sucrose which are important components of several metabolic pathways.

Glycolysis is an important pathway which occurs in almost every living cell, both in prokaryotes and eukaryotes. In this pathway glucose is broken down into 2-3 carbon unit molecules like pyruvate and the energy generated in this pathway is stored in the form of ATP and NADH. - Depending on whether the subsequent steps are aerobic or anaerobic several end products like acetyl CoA and lactic acid, ethanol, acetic acid may be generated.

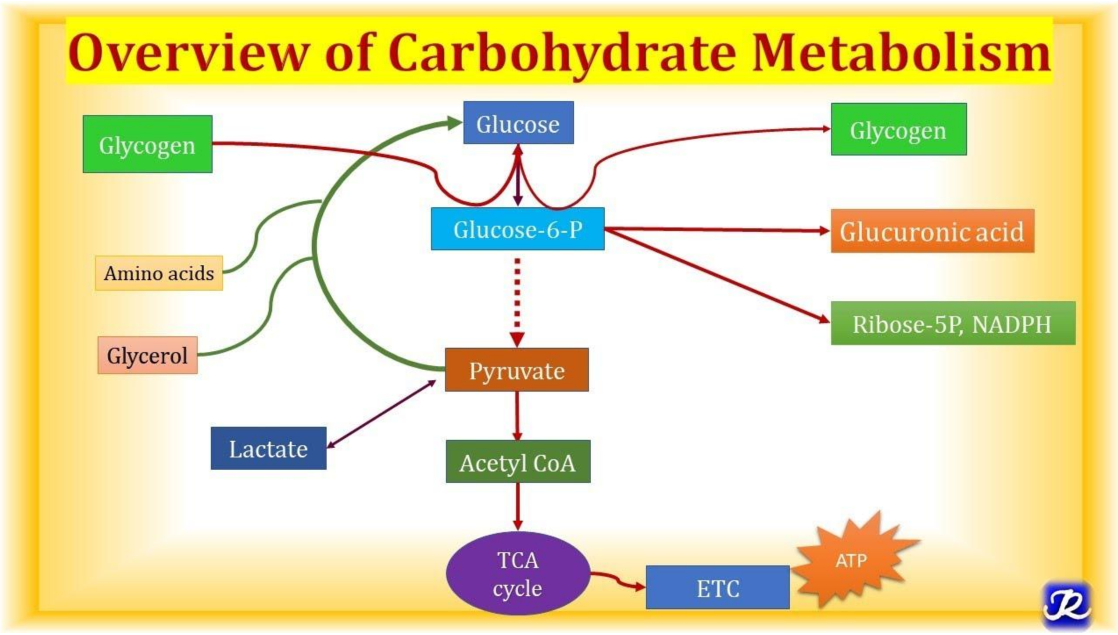

Fig 3 : Metabolism of Carbohydrates

DIETARY FIBRE

DEFINITION

Dietary fibre is made up of the indigestible parts or compounds of plants, which pass relatively unchanged through our stomach and intestines. Fibre is mainly a carbohydrate.

Dietary fibre or roughage is the portion of plant-derived food that cannot be completely broken down by human digestive enzymes. Dietary fibres are diverse in chemical composition, and can be grouped generally by their solubility, viscosity, and fermentability, which affects how fibres are processed in the body. Dietary fibre is defined to be plant components that are not broken down by human digestive enzymes.

A diet high in regular fiber consumption is generally associated with supporting health and lowering the risk of several diseases. Dietary fiber consists of non-starch polysaccharides and other plant components such as cellulose, resistant starch, resistant dextrins, inulin, lignins, chitins (in fungi), pectins, beta-glucans, and oligosaccharides.

TYPES - SOLUBLE AND INSOLUBLE FIBRE

Dietary fiber has two main components: soluble fibre and insoluble fibre, which are components of plant-based foods, such as legumes, whole grains and cereals, vegetables, fruits, and nuts or seeds.

Soluble fibre (*fermentable fibre* or *prebiotic fibre*)

This is one which dissolves in water and is generally fermented in the colon into gases and physiologically active by-products, such as short-chain fatty acids produced in the colon by gut bacteria. Examples are beta-glucans (in oats, barley, and mushrooms) and raw guar gum. Psyllium – a soluble, viscous, nonfermented fibre is a bulking fibre that retains water as it moves through the digestive system, easing defecation. Soluble fibre is generally viscous and delays gastric emptying which, in humans, can result in an extended feeling of fullness.

Inulin (in chicory root), wheat dextrin, oligosaccharides, and resistant starches (in legumes and bananas), are soluble non-viscous fibres. Regular intake of soluble fibres, such as beta-glucans from oats or barley, has been established to lower blood levels of LDL cholesterol, a risk factor for cardiovascular diseases. Soluble fibre supplements also significantly lower LDL cholesterol.

Insoluble fibre

This is one which does not dissolve in water and is inert to digestive enzymes in the upper gastrointestinal tract. Examples are wheat bran, cellulose, and lignin. Coarsely ground insoluble fibre triggers the secretion of mucus in the large intestine, providing bulking. Finely ground insoluble fibre does not have this effect and can actually have a constipating effect. Some forms of insoluble fibre, such as resistant starches, can be fermented in the colon.

SOURCES OF FIBRE

Dietary fiber is found only in plant foods: fruits, vegetables, nuts and grains. Meat, milk and eggs do not contain fiber. The form of food may or may not affect its fiber content.

Canned and frozen fruits and vegetables contain just as much fiber as raw ones. Other types of processing, though, may reduce fiber content. Drying and crushing, for example, destroy the water-holding qualities of fiber.

The removal of seeds, peels or hulls also reduces fiber content. Whole tomatoes have more fiber than peeled tomatoes, which have more than tomato juice. Likewise, whole wheat bread contains more fiber than white bread.

Food sources of dietary fiber have traditionally been divided according to whether they provide soluble or insoluble fiber. Plant foods contain both types of fiber in varying amounts, according to the fiber characteristics of viscosity and fermentability. Advantages of consuming fiber depend upon which type of fiber is consumed and which benefits may result in the gastrointestinal system.

Bulking fibers – such as cellulose and hemicellulose (including psyllium) – absorb and hold water, promoting bowel movement regularity. Viscous fibers – such as beta-glucan and psyllium – thicken the fecal mass. Fermentable fibers – such as resistant starch, xanthan gum, and inulin – feed the bacteria and microbiota of the large intestine, and are metabolized to yield short-chain fatty acids, which have diverse roles in gastrointestinal health.

Dietary fibre is found in plants, typically eaten whole, raw or cooked, although fiber can be added to make dietary supplements and fiber-rich processed foods. Grain bran products have the highest fiber contents, such as crude corn bran (79 g per 100 g) and crude wheat bran (43 g per 100 g), which are ingredients for manufactured foods.

Plant sources

Some plants contain significant amounts of soluble and insoluble fibre. For example, plums and prunes have a thick skin covering a juicy pulp. The skin is a source of insoluble fiber, whereas soluble fiber is in the pulp. Grapes also contain a fair amount of fibre.

Soluble fibre

Found in varying quantities in all plant foods, including:

- legumes (peas, soybeans, lupins and other beans)
- oats, rye, chia, and barley
- some fruits (including figs, avocados, plums, prunes, berries, ripe bananas, and the skin of apples, quinces and pears)
- certain vegetables such as broccoli, carrots, and Jerusalem artichokes

- root tubers and root vegetables such as sweet potatoes and onions (skins of these are sources of insoluble fiber also)
- psyllium seed husks (a mucilage soluble fiber) and flax seeds
- nuts, with almonds being the highest in dietary fibre

Insoluble fibre

Sources include:

- whole grain foods
- wheat and corn bran
- legumes such as beans and peas
- nuts and seeds
- potato skins
- lignans
- vegetables such as green beans, cauliflower, zucchini (courgette), celery, and nopal
- some fruits including avocado, and unripe bananas
- the skins of some fruits, including kiwifruit, grapes and tomatoes.

PHYSIOLOGICAL EFFECTS OF DIETARY FIBRE

Increases food volume without increasing caloric content to the same extent as digestible carbohydrates, providing satiety which may reduce appetite (both insoluble and soluble fibre)

Attracts water and forms a viscous gel during digestion, slowing the emptying of the stomach, shortening intestinal transit time, shielding carbohydrates from enzymes, and delaying absorption of glucose, which lowers variance in blood sugar levels (soluble fibre)

Lowers total and LDL cholesterol, which may reduce the risk of cardiovascular disease (soluble fibre)

Regulates blood sugar, which may reduce glucose and insulin levels in diabetic patients and may lower risk of diabetes (insoluble fibre)

Speeds the passage of foods through the digestive system, which facilitates regular defecation (insoluble fibre)

Adds bulk to the stool, which alleviates constipation (insoluble fiber)

Balances intestinal pH and stimulates intestinal fermentation production of short-chain fatty acids.

Fibre does not bind to minerals and vitamins and therefore does not restrict their absorption, but rather evidence exists that fermentable fibre sources improve absorption of minerals, especially calcium.

ROLE OF FIBRE IN HUMAN NUTRITION

i) Prevent constipation

Insoluble fiber binds water, making stools softer and bulkier, therefore, fibre especially that found in whole grain products is helpful in the treatment and prevention of constipation, hemorrhoids and diverticulosis.

Diverticula are pouches of the intestinal wall that can become inflamed and painful. • In the past, a low-fiber diet was prescribed for this condition.

A high-fiber diet gives better results once the inflammation has subsided.

ii) Lower cholesterol levels

Low blood cholesterol levels (below 200 mg/dl.) have been associated with a reduced risk of coronary heart disease.

The body eliminates cholesterol through the excretion of bile acids. Water-soluble fiber binds bile acids, and hence a high-fiber diet may result in an increased excretion of cholesterol.

Some types of fiber appear to have a greater effect than others.

The fiber found in rolled oats is more effective in lowering blood cholesterol levels than the fiber found in wheat.

Pectin has a similar effect in that it, too, can lower the amount of cholesterol in the blood.

iii) Reduce the risk of some cancers

Dietary fibre may help reduce the risk of some cancers, especially colon cancer.

This idea is based on information that insoluble fibre increases the rate at which wastes are removed from the body.

This means the body may have less exposure to toxic substances produced during digestion.

A diet high in animal fat and protein also may play a role in the development of colon cancer.

iv) Useful for losing weight

High-fibre diets may be useful for people who wish to lose weight.

Fiber itself has no calories, yet provides a "full" feeling because of its water-absorbing ability.

For example, an apple is more filling than a half cup of apple juice that contains about the same calories.

Foods high in fibre often require more chewing, so a person is unable to eat a large number of calories in a short amount of time.

Several health benefits have been attributed to fiber consumption, including:

lower cholesterol and decreased risk of developing cardiovascular disease

decreased mortality risk from circulatory, digestive, and inflammatory diseases

reduced risk of developing some forms of cancer

improved insulin sensitivity and glycemic control

weight and appetite control

prevention and relief from constipation

decreased inflammation increased calcium absorption and bone mineral density.

Foods which are naturally high in fiber also contain many other nutrients that are beneficial to health. Vitamins, minerals, trace elements, polyphenols, alkylresorcinols, and carotenoids found in fiber-rich foods such as wholegrain wheat and rye have been shown to decrease risk for developing type 2 diabetes, cardiovascular disease, and overweight.

REQUIREMENTS OF DIETARY FIBRE

Recommendations around adequate intakes of dietary fibre differ around the world and by age group, but 25-30 g or more daily is widely recommended for adults.If the goal is to add more fiber to the diet, there are lots of great options. Fruits, vegetables, grains, beans, peas and lentils helps to reach that daily fibre goal.

Fibre-rich foods have a mix of different fiber types.

- Some fibre helps keep stool moving in the large intestine.
- Other types of fibre help a person feel full for longer. That can lower the overall calories consumed and help with weight control.
- And a diet rich in dietary fibre in general has been linked to lower levels of heart disease.

The suggested amount of daily fibre depends on your age and how many calories you take in each day.

Current dietary guidelines for Americans suggest that people aged 2 and older get 14 grams of fibre for every 1,000 calories in the daily diet. For children ages 12 months through 23 months, the guidelines suggest getting 19 grams of fibre a day.

WATER - FUNCTIONS

Water

Water is essential to most bodily functions.

The body has no way to store water and needs fresh supplies every day.

The best source of fluids is fresh tap water.

A child will need different amounts of fluid, depending on their age and gender.

Women should have about 2 litres (8 cups) of fluids a day, and men about 2.6 litres (10 cups).

People who are pregnant or breastfeeding need more fluid each day than usual.

Dehydration can happen when the body's fluids are low. It can be life threatening, especially to babies, children and the elderly.

The human body can last weeks without food, but only days without water.

The body is made up of 50 to 75% water. Water forms the basis of blood, digestive juices, urine and perspiration, and is contained in lean muscle, fat and bones.

As the body can't store water, we need fresh supplies every day to make up for losses from the lungs, skin, urine and faeces (poo). The amount we need depends on our body size, metabolism, the weather, the food we eat and our activity levels.

Most foods, even those that look hard and dry, contain water. The body can get about 20% of its total water requirements from solid foods alone.

The process of digesting foods also produces a small amount of water as a by-product which can be used by the body. Water sourced this way can provide around 10% of the body's water requirements.

The remaining 70% or so of water required by the body must come from fluids (liquids).

The amount of fluid a body needs each day depends on several factors, such as:

- gender
- age
- how active a person is
- pregnant or breastfeeding
- the weather
- lifestyle.

FUNCTIONS OF WATER

Water is needed for most body functions, including to:

- Maintain the health and integrity of every cell in the body.
- Keep the bloodstream liquid enough to flow through blood vessels.
- Help eliminate the by-products of the body's metabolism, excess electrolytes (for example, sodium and potassium), and urea, which is a waste product formed through the processing of dietary protein.
- Regulate body temperature through sweating.
- Moisten mucous membranes (such as those of the lungs and mouth).
- Lubricate and cushion joints.
- Reduce the risk of urinary tract infections (UTIs), such as cystitis by keeping the bladder clear of bacteria.
- Aid digestion and prevent constipation.
- Moisturize the skin to maintain its texture and appearance.
- Carry nutrients and oxygen to cells.
- Serve as a shock absorber inside the eyes, spinal cord and in the amniotic sac surrounding the foetus in pregnancy.

WATER COMPARTMENTS

The body's fluid separates into two main compartments: Intracellular fluid volume (ICFV) and extracellular fluid volume (ECFV). Of the 42L of water found in the body, two-thirds of it is within the intracellular fluid (ICF) space, which equates to 28L.

Body fluids can be discussed in terms of their specific fluid compartment, a location that is largely separate from another compartment by some form of a physical barrier. The intracellular fluid (ICF) compartment is the system that includes all fluid enclosed in cells by their plasma membranes. Extracellular fluid (ECF) surrounds all cells in the body. Extracellular fluid has two primary constituents: the fluid component of the blood (called plasma) and the interstitial fluid (IF) that surrounds all cells not in the blood.

Intracellular Fluid

The ICF lies within cells and is the principal component of the cytosol/cytoplasm. The ICF makes up about 60 percent of the total water in the human body, and in an average-size adult male, the ICF accounts for about 25 liters (seven gallons) of fluid. This fluid volume tends to be very stable, because the amount of water in living cells is closely regulated. If the amount of water inside a cell falls to a value that is too low, the cytosol becomes too concentrated with solutes to carry on normal cellular activities; if too much water enters a cell, the cell may burst and be destroyed.

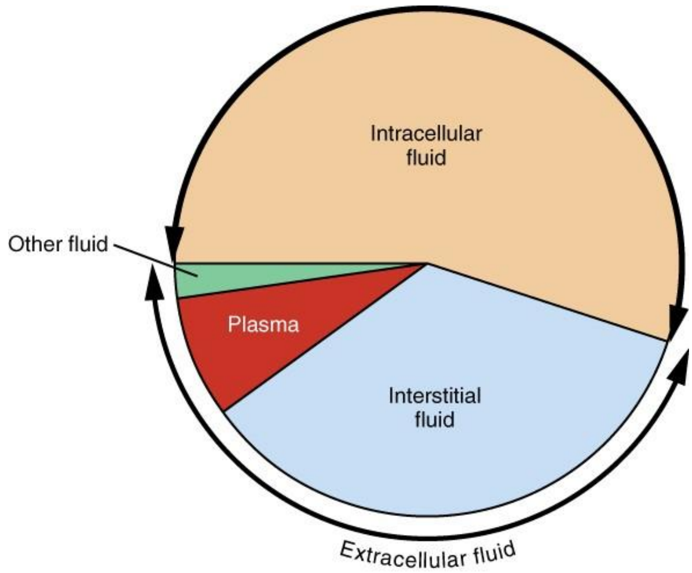

Fig 4 : Water Compartments in the body

Extracellular Fluid

The ECF accounts for the other one-third of the body's water content. Approximately 20 percent of the ECF is found in plasma. Plasma travels through the body in blood vessels and transports a range of materials, including blood cells, proteins (including clotting factors and antibodies), electrolytes, nutrients, gases, and wastes. Gases, nutrients, and waste materials travel between capillaries and cells through the IF. Cells are separated from the IF by a selectively permeable cell membrane that helps regulate the passage of materials between the IF and the interior of the cell.

The body has other water-based ECF. These include the cerebrospinal fluid that bathes the brain and spinal cord, lymph, the synovial fluid in joints, the pleural fluid in the pleural cavities, the pericardial fluid in the cardiac sac, the peritoneal fluid in the peritoneal cavity, and the aqueous humor of the eye. Because these fluids are outside of cells, these fluids are also considered components of the ECF compartment.

Co**mposition of Body Fluids**

The compositions of the two components of the ECF—plasma and IF—are more similar to each other than either is to the ICF. Blood plasma has high concentrations of sodium, chloride, bicarbonate, and protein. The IF has high concentrations of sodium, chloride, and bicarbonate, but a relatively lower concentration of protein. In contrast, the ICF has elevated amounts of potassium, phosphate, magnesium, and protein. Overall, the ICF contains high concentrations of potassium and phosphate, whereas both plasma and the ECF contain high concentrations of sodium and chloride.

REGULATION & WATER BALANCE

In a day, there is an exchange of about 10 liters of water among the body's organs. The osmoregulation of this exchange involves complex communication between the brain, kidneys, and endocrine system. A homeostatic goal for a cell, a tissue, an organ, and an entire organism is to balance water output with water input.

Regulation of Daily Water Input

Total water output per day averages 2.5 liters. This must be balanced with water input. Our tissues produce around 300 milliliters of water per day through metabolic processes. The remainder of water output must be balanced by drinking fluids and eating solid foods. The average fluid consumption per day is 1.5 liters, and water gained from solid foods approximates 700 milliliters.

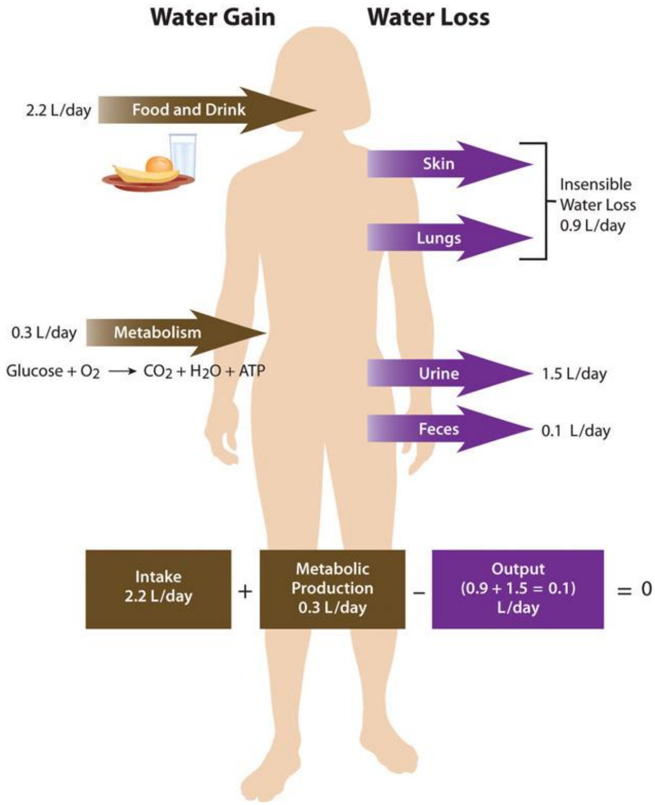

Fig 5 : Daily fluid loss and gain

Thirst Mechanism

Thirst is an osmoregulatory mechanism to increase water input. The thirst mechanism is activated in response to changes in water volume in the blood, but is even more sensitive to changes in blood osmolality. Blood osmolality is primarily driven by the concentration of sodium cations. The urge to drink results from a complex interplay of hormones and neuronal responses that coordinate to increase water input and contribute toward fluid balance and composition in the body.

The “thirst center” is contained within the hypothalamus, a portion of the brain that lies just above the brainstem. In older people the thirst mechanism is not as responsive and as we age there is a higher risk for dehydration. Thirst happens in the following sequence of physiological events:

Receptor proteins in the kidney, heart, and hypothalamus detect decreased fluid volume or increased sodium concentration in the blood. Hormonal and neural messages are relayed to the brain’s thirst center in the hypothalamus. The hypothalamus sends neural signals to higher sensory areas in the cortex of the brain, stimulating the conscious thought to drink. Fluids are consumed. Receptors in the mouth and stomach detect mechanical movements involved with fluid ingestion. Neural signals are sent to the brain and the thirst mechanism is shut off.

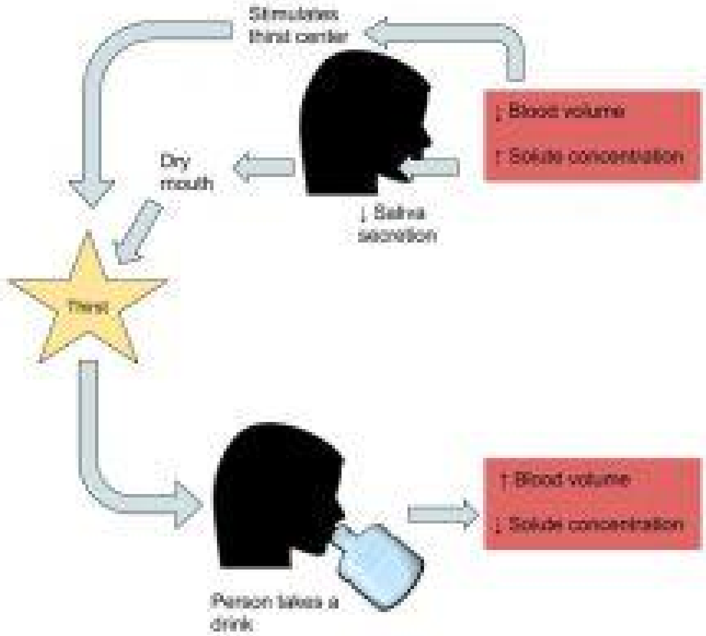

Fig 6 : Regulating water intake

The physiological control of thirst is the backup mechanism to increase water input. Fluid intake is controlled primarily by conscious eating and drinking habits dependent on social and cultural influences. For example, you might have a habit of drinking a glass of orange juice and eating a bowl of cereal every morning before school or work.

Regulation of Daily Water Output

The daily water output averages 2.5 liters. There are two types of outputs. The first type is insensible water loss, meaning we are unaware of it. The body loses about 400 milliliters of its daily water output through exhalation. Another 500 milliliters is lost through our skin. The second type of output is sensible water loss, meaning we are aware of it. Urine accounts for about 1,500 milliliters of water output, and feces account for roughly 100 milliliters of water output. Regulating urine output is a primary function of the kidneys, and involves communication with the brain and endocrine system.

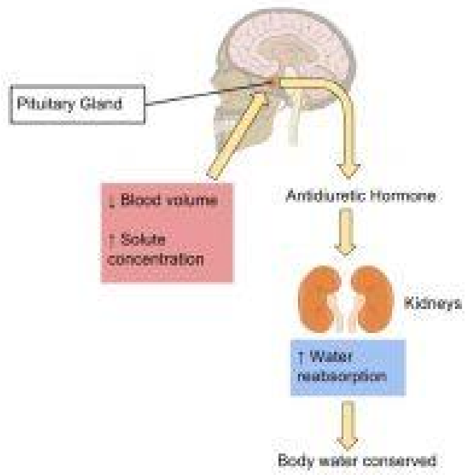

Fig 7 : Regulating water output

The kidneys are two bean-shaped organs, each about the size of a fist and located on either side of the spine just below the rib cage. The kidneys filter about 190 liters of blood and produce (on average) 1.5 liters of urine per day. Urine is mostly water, but it also contains electrolytes and waste products, such as urea. The amount of water filtered from the blood and excreted as urine is dependent on the amount of water in, and the electrolyte composition in the blood.

Kidneys have protein sensors that detect blood volume from the pressure, or stretch, in the blood vessels of the kidneys. When blood volume is low, kidney cells detect decreased pressure and secrete the enzyme, renin. Renin travels in the blood and cleaves another protein into the active hormone, angiotensin. Angiotensin targets three different organs (the adrenal glands, the hypothalamus, and the muscle tissue surrounding the arteries) to rapidly restore blood volume and, consequently, pressure.

The Hypothalamus Detects Blood Osmolality

Sodium and fluid balance are intertwined. Osmoreceptors (specialized protein receptors) in the hypothalamus detect sodium concentration in the blood. In response to a high sodium level, the hypothalamus activates the thirst mechanism and concurrently stimulates the release of antidiuretic hormone. Thus, it is not only kidneys that stimulate antidiuretic- hormone release, but also the hypothalamus. This dual control of antidiuretic hormone release allows for the body to respond to both decreased blood volume and increased blood osmolality.

The Adrenal Glands Detect Blood Osmolality

Cells in the adrenal glands sense when sodium levels are low and potassium levels are high in the blood. In response to either stimulus, they release aldosterone. Aldosterone is released in response to angiotensin stimulation and is controlled by blood electrolyte concentrations. In either case, aldosterone communicates the same message, to increase sodium reabsorption and consequently water reabsorption. In exchange, for the reabsorption of sodium and water, potassium is excreted.

DISORDERS OF WATER BALANCE

There are three types of dehydration: hypotonic or hyponatremic, hypertonic or hypernatremic, and isotonic or isonatremic.

Hypotonic dehydration is primarily a loss of electrolytes, sodium in particular.

Hypertonic dehydration is primarily a loss of water.

Hyponatremia

It frequently occurs in hospitalized patients because acute illnesses often promote antidiuretic hormone (ADH) secretion. Outside the hospital, hyponatremia can be a side effect of medications, most notably thiazide diuretics and antidepressants, and it is a common problem among alcoholics, particularly heavy beer drinkers. Identifying the cause of persistent hyponatremia is important, because it can be an indication of serious, unsuspected underlying illnesses, such as adrenal insufficiency and small cell lung cancer. Hyponatremia can also develop in patients with heart failure and hepatic cirrhosis, and its appearance portends a bad prognosis. Chronic hyponatremia, even when mild, causes impaired cognition, gait disturbances, osteoporosis, falls and fractures. Very low serum sodium concentrations can result in serious neurological complications, either from hyponatremia itself, or from overzealous efforts to correct it.

Hypernatremia

It represents a state of relative excess of Na^+ to water in the ECF. Causes for hypernatremia include primary water deficit (with or without Na^+ loss) and Na^+ gain (Table 2). Water deficit is the most common cause of hypernatremia that develops either from inadequate intake or increased loss of free water. Advanced age, dementia, mental status changes can lead to inadequate access to water.

Adipsic hypernatremia (sometimes called essential hypernatremia) results from congenital or acquired defect in hypothalamic osmoreceptors. It is associated with partial or complete loss of osmoregulation of vasopressin, lack of thirst, hypernatremia and evidence of hypovolemia. Patients with this condition may have associated elevated renin and aldosterone, hypokalemia and alkalosis.

Hyponatremia and hypernatremia represent disorders of water balance. Impaired renal water excretion and ADH play an important role in hyponatremia, while excess water loss leads to hypernatremia. Both hyponatremia and hypernatremia present with non-specific neurological symptoms and the physician must recognize these electrolyte imbalances as a cause for reversible encephalopathy. Meticulous clinical history and physical examination with the help of laboratory studies point to the cause for hypo- or hypernatremia and guide therapy. Careful correction of sodium level is warranted to avoid fatal neurological sequelae.

Dehydration

Dehydration occurs when the water content of the body is too low. This is easily fixed by increasing fluid intake.

Symptoms of dehydration

Symptoms of dehydration include:

- thirst
- headaches
- lethargy
- mood changes and slow responses
- dry nasal passages
- dry or cracked lips
- dark-coloured urine
- weakness
- tiredness
- confusion and hallucinations.

If dehydration is not corrected by fluid intake, eventually urination stops, the kidneys fail, and the body can’t remove toxic waste products. In extreme cases, dehydration may result in death.

Causes of dehydration

There are several factors that can cause dehydration including:

- not drinking enough water
- increased sweating due to hot weather, humidity, exercise or fever
- insufficient signalling mechanisms in the elderly – sometimes, older adults do not feel thirsty even though they may be dehydrated
- increased output of urine due to a hormone deficiency, diabetes, kidney disease or medications
- diarrhoea or vomiting
- recovering from burns.

Risk of dehydration

Anyone can experience dehydration but there are some people who can be more at risk, such as:

- babies
- children
- the elderly.

Babies and children

Babies and children are susceptible to dehydration, particularly if they are ill. Vomiting, fever and diarrhoea can quickly cause dehydration.

Dehydration can be a life-threatening condition in babies and children. If you suspect dehydration, take your baby or child to the nearest hospital emergency department immediately.

Some of the symptoms of dehydration in babies and children include:

- cold skin
- lethargy
- dry mouth
- blue tinge to the skin (as circulation slows down)
- depressed fontanelle in babies (soft spot on top of the skull where the bones are yet to close).

Elderly people

Older people are often at risk of dehydration due to:

- changes to kidney function (declines with age)
- hormonal changes
- not feeling thirsty (body mechanisms that trigger thirst do not work as well as we age)
- medication (for example, diuretics and laxatives)
- chronic illness
- heat stress
- limited mobility.

Getting the right balance of fluid intake

Not drinking enough water can increase the risk of kidney stones and, in women, urinary tract infections (UTIs). It can also lower your physical and mental performance, and your salivary gland function, and lead to dehydration.

Water intoxication (hyponatraemia)

Drinking too much water can damage the body and cause hyponatraemia (water intoxication), although it is rare in the general population.

Hyponatraemia occurs when sodium in the blood, which is needed for muscle contraction and sending nerve impulses, drops to a dangerously low level.

If large amounts of plain water are consumed in a short period of time, the kidneys cannot get rid of enough fluid through urine and the blood becomes diluted.

Hyponatraemia can lead to:

- headaches
- blurred vision
- cramps (and eventually convulsions)
- swelling of the brain
- coma and possibly death.

For water to reach toxic levels, many litres of water would have to be consumed in a short period of time.

Hyponatraemia tends to occur in people with particular diseases or mental illnesses (for example, in some cases of schizophrenia), endurance athletes and in infants who are fed infant formula that is too diluted.

Fluid retention

Edema, also spelled oedema, and also known as fluid retention, dropsy, hydropsy and swelling, is the build-up of fluid in the body's tissue. Most commonly, the legs or arms are affected. Symptoms may include skin which feels tight, the area may feel heavy, and joint stiffness.

Oedema is a build-up of fluid in the body which causes the affected tissue to become swollen. The swelling can occur in one particular part of the body or may be more general, depending on the cause.

Many people believe that drinking water causes fluid retention (or oedema). In fact, the opposite is true. Drinking water helps the body rid itself of excess sodium, which results in less fluid retention.

The body will retain fluid if there is too little water in the cells. If the body receives enough water on a regular basis, there will be no need for it to hold onto water and this will reduce fluid retention.

Symptoms of edema include:

- Swelling or puffiness of the tissue right under the skin, especially in legs or arms.
- Stretched or shiny skin.
- Skin that holds a dimple, also known as pitting, after it's been pressed for a few seconds.
- Swelling of the belly, also called the abdomen, so that it's bigger than usual.
- Feeling of leg heaviness.

Causes

Edema occurs when tiny blood vessels in the body, also known as capillaries, leak fluid. The fluid builds up in nearby tissues. The leak leads to swelling.

Causes of mild cases of edema include:

- Sitting or staying in one position for too long.
- Eating too much salty food.
- Being premenstrual.
- Being pregnant.

Edema also can be a side effect of some medicines. These include:

- High blood pressure medicines.
- Nonsteroidal anti-inflammatory medicines.
- Steroid medicines.
- Estrogens.

Certain diabetes medicines called thiazolidinediones.

Medicines use to treat nerve pain.

Sometimes edema can be a sign of a more serious condition. Illnesses that can cause edema include:

Congestive heart failure. Congestive heart failure causes one or both of the heart's lower chambers stop pumping blood well. As a result, blood can back up in the legs, ankles and feet, causing edema.

Congestive heart failure can also cause swelling in the stomach area. This condition also can cause fluid to build up in the lungs. Known as pulmonary edema, this can lead to shortness of breath.

Liver damage. This liver damage from cirrhosis can cause fluid to build up in the stomach area. and in the legs. This fluid buildup in the stomach area is known as ascites.

Kidney disease. Kidney disease can cause fluid and salts in the blood to build up. Edema linked to kidney disease usually occurs in the legs and around the eyes.

Kidney damage. Damage to the tiny, filtering blood vessels in the kidneys can result in nephrotic syndrome. In nephrotic syndrome, decreased levels of protein in the blood can lead to edema.

Weakness or damage to veins in your legs. This condition, known as chronic venous insufficiency, harms the one-way valves in the leg. One-way valves keep blood flowing in one direction. Damage to the valves allows blood to pool in the leg veins and causes swelling.

Deep vein thrombosis, also called DVT. Sudden swelling in one leg with pain in the calf muscle can be due to a blood clot in one of the leg veins. DVT requires medical help right away.

Problems with the system in the body that clears extra fluid from tissues. If the body's lymphatic system is damaged, such as by cancer surgery, the lymphatic system might not drain well.

Severe, long-term lack of protein. An extreme lack of protein in the diet over time can lead to edema.

Treatment

Mild edema usually goes away on its own. Wearing compression garments and raising the affected arm or leg higher than the heart helps.

Medicines that help the body get rid of too much fluid through urine can treat worse forms of edema. One of the most common of these water pills, also known as diuretics, is furosemide (Lasix). A health care provider can decide about the need for water pills.

Treating the cause of the swelling is often the focus over time. If edema is a result of medicines, for example, a care provider might change the dose or look for another medicine that doesn't cause edema.

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