Chapter 7: Water

7.1 Water Needs

The sensation of thirst makes water unique compared to other dietary constituents. Thirst is a true neurological bio-feedback mechanism triggered by the dynamic levels of body water. Thirst is also affected by psycho-social drinking cues like culture, preference, and occasion.

Water is continually turned over in the body with the flux of ionic charges between the intracellular and extracellular fluid compartments. Water turnover, measured using isotope-labeled water tracking, is apparently balanced in humans so that water intake is equal to water losses. In other words, the volume of fluid in the human body, with exception of a very narrow range, doesn't change despite drinking volume.

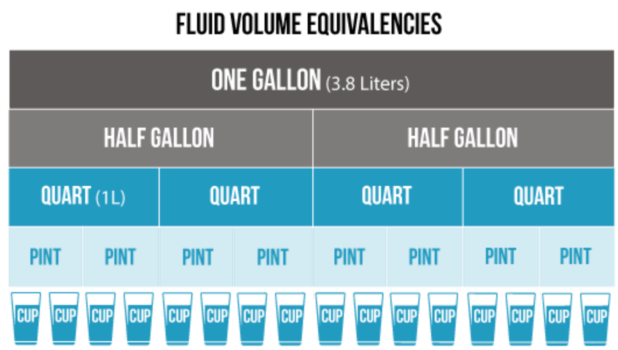


Figure 7.1. Conversions for Fluid Liquids

The **Adequate Intake** (AI) for water reflects the level of intake reported by healthy, hydrated adults, and is higher than the amount established in turnover studies because it includes pre-formed fluids from beverages and food. This level of intake is compatible with optimal serum osmolality, a measure indicative of normal body hydration levels. Since water balance is achieved across a wide range of intakes and other confounding circumstances, the AI guideline should be not be used as a set daily minimum that is required to maintain normal hydration, but rather a reference for median intake. A **Tolerable Upper Intake Level (UL**) was not set for water, as healthy individuals can excrete excess water to maintain water balance. However, acute water toxicity can occur from rapid consumption of quantities of fluids that exceed the kidney's maximal excretion rate of approximately 0.7 to 1.0 L/hour.

FLUID INTAKE Liters	RDA/AI	
	Men	Women
Food & beverage	3.7	2.7

Figure 7.2. Adequate Fluid Intake

Typical sedentary healthy adults require between 2.5 (women) and 3 (men) liters of water per day. Individuals who are physically active or exposed to hotter environmental temperatures may have a higher daily need for water to replace thermoregulatory losses. Neither moderate intake of alcohol nor caffeine significantly impacts total body water status, as their diuretic effect is fast-acting and transient.

While nutrition experts agree that plain water should constitute the majority of one's fluid intake, the optimal amount of water intake in a well-balanced diet has been the subject of considerable public and scientific debate in the past. More modern healthy eating guidelines are focusing on ideal fluid intake levels while factoring in water additives, especially those that contribute calories and sugar.

7.1 Homework 1

Homework • Answered

Select the answer that best completes this sentence:
The adequate intake for water is based on fluid intake from ______________ .

- ◉ **A** beverages and food
- ○ **B** plain beverages
- ○ **C** beverages minus metabolic water
- ○ **D** food in absence of metabolic water

Answered - Correct!

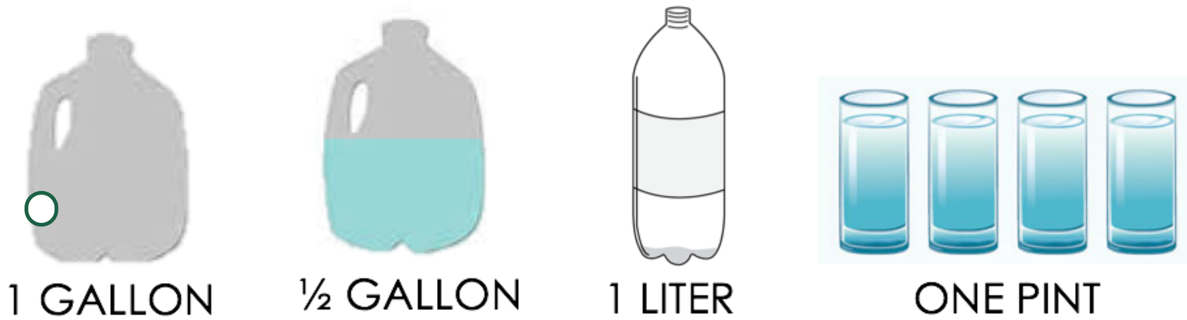
1 attempt left Retry

7.2 Homework 2

Homework • Answered

Touch the image that shows the volume of water closest to the *average* adequate daily intake for men and women

✓ Correct!



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You can place up to 1 targets

Answered - Correct!

1 attempt left Retry

7.2 Water Sources

Fluids are provided in the diet by **drinking plain water** and **formulated beverages** and consuming **foods** that contain water. It is estimated that more than 75% of daily fluid intake in the US is from beverages and around 25% is from plain drinking water.

Plain drinking water in the diet can be obtained from the faucets of homes attached to municipal water treatment facilities, ground wells, and from commercially bottled retail sources. Faucet, or tap, water is collected from a variety of natural surface and ground resources including rivers, lakes and reservoirs and transported via pipes to municipally governed treatment works. The collected water is cleaned by one or

Figure 7.3. Plain Water

more federally approved sanitation methods, and then either stored in above-ground towers or underground reservoirs, or routed to smaller mains and piping networks beneath towns and cities.

Standards for municipal water are set by each state at a level that is equivocal to, or more stringent than, EPA safe levels standards. The EPA has two levels of standards for tap water. The primary standards limit high-risk contaminates like bacteria and toxic minerals. The secondary standards only target the sensory quality of water. These secondary standards include criteria for taste, color and total dissolved solids (TDS). TDS is the sum of inorganic calcium, magnesium, potassium, sodium, bicarbonate, chloride, and sulfate salts, and a small amount of non-toxic organic matter, that are dissolved in water. The EPA level for satisfactory TDS in city tap water is 500 mg/L—a level achieved primarily by flocculation techniques and micron filtration. Reverse osmosis and distillation are other separation techniques that are used to purify collected groundwater. **In reverse osmosis**, water is forced through semipermeable membranes that are impermeable to minerals and other contaminants, that include the mineral salts mentioned above and in some productions, even smaller trace compounds like **arsenic**, lead, boron, chromium, and copper. These levels are carefully monitored by city water facilities and must be limited to values that are expressed in parts per million, or even billion.

In most cases, EPA water standards for primary level contaminants require secondary disinfection treatments. Chlorine and chloramine treatments are the most used, and least expensive, techniques used to disinfect municipal water. Water is considered safe for drinking if limits for chloramine and chlorine are less than 4 milligrams per liter (mg/L) or 4 parts per million (ppm). Recently, many municipalities have switched to **ozonation** methods to ensure microbial control. Ozone gas – the same type found in the atmosphere created by subjecting oxygen to electrical current – kills microorganisms and then naturally breaks down and leaves the water quickly. As an additional benefit, when ozone molecules degrade, free oxygen ions are made available to bond with other contaminants like iron and sulfur to form insoluble oxides that are precipitated or filtered out. Other water treatments that are effective for microbial control include exposing water to **ultraviolet (UV)**light. This sanitation method is chemical-free, as the light damages microorganisms at the cellular level, either killing them or stopping them from replicating. Data for these disinfection treatment protocols and attendant risks is rigorously collected and reviewed, and made available to the public annually through city water departments and the EPA.

Additional filtration can be achieved by home faucet devices or other home filtration products such as pitchers, straws and even coconut skins. These products can eliminate TDS and remove hard minerals which, "softens" water and improves taste and saponification capabilities. To select the best filter for one's home, and the extent of improvement to expect after home filtration, depends upon his or her understanding of the

Figure 7.4. At Home Water Filtration

mineral salts present their home's tap water. If the minerals are high in calcium or magnesium salts, for example, the water may taste bitter, and treatment should include softening. If the water is high in sodium, chloride, or potassium salts, the water tastes more brackish and salty and may be best treated with reverse osmosis. Water should be tested and diagnosed before a high-priced home installation system is selected. For many mainstream filtration products, reductions in large mineral molecules and chlorine is comparable to, or less significant than, reductions in many purified bottled water beverages.

Figure 7.5. Bottled Water from Municipal Sources

Like other commercial packed foods and drinks, bottled water is overseen by the Food and Drug Administration (FDA). The **FDA** standard of identity for "**bottled water"** restricts the use of any added carbonation or flavoring, and requires sanitary food-grade packaging. The FDA also requires bottled water manufactures to include the source of the water, along with the secondary processing treatment used on the label if the water was **municipally sourced**. Approximately 40% of bottled water is municipally or "publicly" sourced. This type of water is collected from the same city tap water lines that supply residential faucets. The secondary filtration treatments used for purifying bottled water (e.g., osmosis and microfiltration) are the same as those used by city systems. While the labeling and manufacturing standards for bottled water are separately regulated by the FDA, for municipally sourced bottled water, its safety and quality is technically ensured by the EPA through the regulatory oversight of city water.

The safety of non-municipally sourced water like those from natural springs or wells, both mineral and artisanal types, must also be properly labeled in compliance with FDA laws. The safety of this water is also regulated by industry quality standard organizations, like the IBWO which, in coordination with the EPA, determine the best practices for water collecting and bottling. The standards for non-municipal water are tailored to the nature of the water source, and how the water is collected and subsequently bottled. Spring water, the most consumed type, is typically gathered and transported for processing and purification and bottling away from the collection site. Some brands, like Arrowhead®, advertise their water as collected at the

Figure 7.6. Bottled Water from Non-Municipal Natural Sources

Figure 7.7. Bottled Beverages

site of a mountain spring. Regulatory criteria for these statements ensure that the drilled water matches the composition as the water at the surface of the spring, and in the case of Arrowhead®, that it was not transported for bottling. Unlike spring water, which has TDS levels of approximately 50 ppm, mineral waters tout their TDS and must have levels of at least 250 ppm, which demonstrates that not all TDS are bad. High end mineral waters can have TDS levels as high as 3,050 ppm, which is around the same amount as electrolyte sports beverages like Gatorade®. The criteria for sparkling water is that it must be sourced from naturally carbonated springs or artisan wells. Glacier water that has not circulated to the ground is clearest and, thus, possesses the lowest TDS levels of all waters, or just 5ppm.

More than one-fifth of the calories in the diet is provided by fluids from **beverages** that include plain water and at least one other component that is present naturally or added to enhance the beverage. Formulated and bottled beverages that are made with water as the primary ingredient are grouped into many overlapping categories including, but not limited to, caffeinated, alcoholic, sweetened, carbonated and supplemental nutrition beverages.

Throughout human history, water has been used as a medium for extracting physiologically functional plant compounds, like caffeine. Nearly 100% of the caffeine in the diet is from fluid beverages. **Coffee** is the largest source of water intake from beverage categories followed by soft drinks and **teas,** in that order. Caffeine is traditionally extracted from coffee beans and tea leaves using steeping methods that require heat and water. Cold brew methods have grown in popularity recently as research suggests polyphenol content is better preserved, and acidity levels are reduced in cold brewing.

Soft drinks are the leading source of added sugar intake in the US, and they represent around 30% of total fluid intake. Sodas are formulated by adding proprietary syrup mixes to an 85% filtered water solution that includes other additives like phosphoric acid. The liquid is then injected with bi-carbonate gasses and pressure sealed. Recent trends in soft drink formulations have us returning to more natural sweeteners and emphasizing the sugar source such as beet, cane, or agave. Diet sodas represent just under half of the total soda intake in the US, and this category too is moving towards more naturally non-nutritive sweeteners, like Stevia (i.e., Truvia), and away from synthetic, non-digestible ones, like sucralose.

Fruit and vegetable juices are also classified as beverages and contribute significantly to fluid and added sugar intake in the US. Whole fruit, extracted of its edible flesh, is better viewed as a whole food, like milk, that provides fluids in the diet in a proportion that occurs naturally. The whole foods highest in liquids are fruits and vegetables. Fresh fruit is typically more than 90% water by weight. Even fruit and vegetable plants on the lower end of the moisture spectrum that are higher in fiber and starch are 75% water by weight. Milk is another example of a whole liquid food that is included in measures of beverage intake. Milk represents 10% of the total beverage intake in the US. Meats and cooked legumes also provide liquid in the diet, with the average serving from foods in these group providing anywhere from 50-100 mL of water per serving. Nuts are comparable in moisture to legumes, but the amounts consumed are so minimal that they do not have a significant impact on total fluid intake. Grains are the lowest moisture whole food besides processed vegetable chips, jerkies, and fruit leathers.

Water is also used as a medium to produce **alcohol** by bacterial fermentation. One hundred percent of the alcohol in the human diet is consumed in liquid beverages. Alcoholic beverages represent 14% of the overall fluid intake of adults in the US and include numerous categories most simply grouped into beer, wine, and spirits.

7.2 Homework 1

Homework • Answered

Which statement regarding the regulatory oversight of plain drinking water is false?

- ○ **A** Municipal tap water regulations are established by the EPA
- ◉ **B** Municipal tap water facility inspections are conducted by the FDA
- ○ **C** Municipally-sourced bottled water regulations are established by the EPA
- ○ **D** Naturally sourced bottled water labeling regulations are governed by the FDA

Answered - Correct! No attempts left

7.3 Water Processing

Water is not transformed in the human body. Rather, it diffuses into the human body unchanged, where it continuously travels across the body compartments in a controlled and regulated closed-circuit until it encounters any one of the active excretory junctions along the journey.

Fluids from foods and beverages are swallowed and passed through to the stomach relatively unaltered. In the stomach, fluids mix with acidic digestive juices to form an acidic and high dissolving digestive medium. Most of the water is absorbed in the large intestine by **diffusion** in response to the **osmotic gradient**, established by high concentrations of sodium in the blood. A relatively small amount of water is excreted in the fecal matter of healthy adults and, depending on fiber intake, is estimated at around 100-200 mL/day.

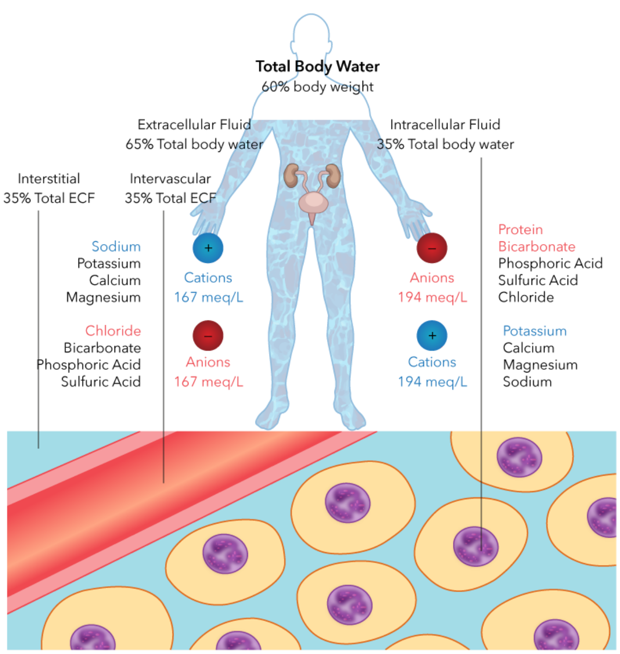

Figure 7.8. Total Body Water Compartmentalization and Electrolyte Composition

Total body water (TBW) is approximately 60% of adult body mass that is distributed between two major body compartments. The **extracellular compartment** contains approximately 65% of total body water and is rich in the cation, sodium and the anions, chloride and bicarbonate. The **intracellular compartment** represents the other 35% of total body water and is characterized by high levels of the cations, potassium and magnesium, and anion proteins. The water equilibrium across the two compartments is maintained by the **electric current** that is generated by the **charged ions** and **active transport-mediated** ion pumps Na^+/K^+-ATPase within cell membranes.

Body water compartmentalization is not static in volume, but rather, represents the net effect of dynamic fluid exchange between compartments. Exchange between the intravascular and interstitial spaces of the ECF occurs through the capillaries of various tissues which have a unique permeability to water and solutes. Water leaves the vascular space by net filtration and moves into the vascular space by net absorption based on transcapillary forces and hydrostatic and oncotic pressures.

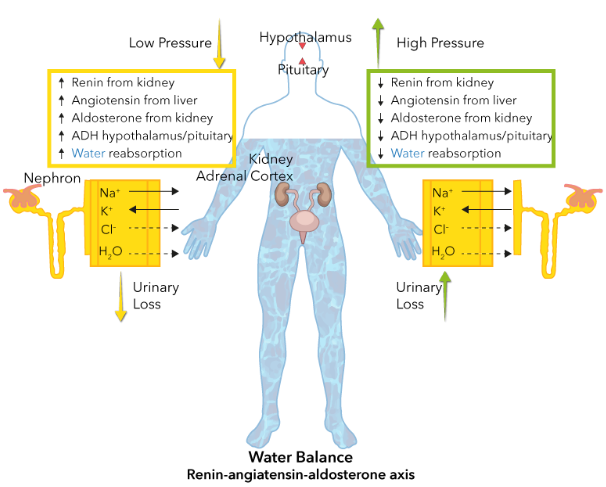

Figure 7.9. Body Water Balance

The volume and composition of the ECF are regulated through **neuroendocrine pathways** that increase or decrease the amount of water that is re-absorbed with circulating plasma water. In response to fluctuations in a set-point serum osmolality of about 280 mOsmol/kg, osmoreceptors in the brain and cell membranes are stimulated. If the **osmotic pressure** is too low, these receptors trigger body water conservation mechanisms that work mainly in the proximal convoluted tubule and thick ascending limb of the **kidneys**.

The process begins with the hypothalamus stimulating the kidney to release **rennin** and **aldosterone** from the proximal **adrenal cortex**. Rennin, in turn, stimulates the liver to release **angiotensin**, which undergoes a series of enzymatic transformations that result in **vasoconstriction** and reduced blood flow to the kidney. Angiotensin also stimulates the release of arginine vasopressin, more commonly known as **anti-diuretic hormone (ADH)**, from the **pituitary** gland. ADH causes an increased concentration of ions in the nephron which results in a higher water **reabsorption** rate. The collective actions result in a net water conservation and quick restoration of water balance. In response to **elevated oncotic pressure** or a reduction in serum osmolality, the opposite reaction happens so that the net amount of **water loss** increases.

Water losses are s also varies depending upon dietary factors and salt load. The quantity of metabolic end products and electrolytes in a typical Western diet that needs excreting is approximately 650 mOsmol per day. This translates to a minimum urine volume of at least 500 ml/day to maintain osmotic balance. The effects of increased varies widely from the general average, estimated around 1 to 2 L/day, to as much as 20 L/day in those consuming large quantities of fluid.

Renal fluid output also varies depending upon dietary factors and salt load. The quantity of metabolic end products and electrolytes in a typical Western diet that need excreting is approximately 650 mOsmol per day. This translates to a minimum urine volume of at least 500 ml/day to maintain osmotic balance. The effects of increased **salt intake** on urine volume in a typical adult is thought to be very small; however, decreasing sodium intake, may reduce urinary output in healthy and hypertensive populations by as much as one-third of a liter per day.

Urea, a major end product of metabolism of **dietary protein**, also requires water for urinary excretion. Renal excretion of 1 g of urea nitrogen requires 40 to 60 mL of water. Thus, if a person consumes 63 g of protein in a diet that contains 2,100 kcal, the volume of water required increases by 0.4 to 0.6 L/day above the basal osmolar excretory requirement of 0.5 L/day. Other dietary constituents also increase urinary water losses, such as **caffeinated** and **alcoholic beverages**, which increase diuresis but only during the initial hours of consumption; later, caffeine and ethanol appear to have a compensatory anti-diuretic effect, which lasts many hours post ingestion. This antidiuretic phase is likely the result of a high serum osmolality that stimulates arginine vasopressin and subsequent water reabsorption. Accordingly, these changes in urinary water losses from ethanol and caffeine may depend on the amount of water consumed at prior meals, but in any event, likely transient enough to not result in appreciable fluid losses over a 24-hour period.

Altitude increases **urinary water losses** by hypoxia-induced diuresis, a condition that results in an oncotic change and a 2 to 3 L total body water loss over several days. The body water deficit and serum protein losses

Figure 7.10. Dietary Factors that Influence Water Losses

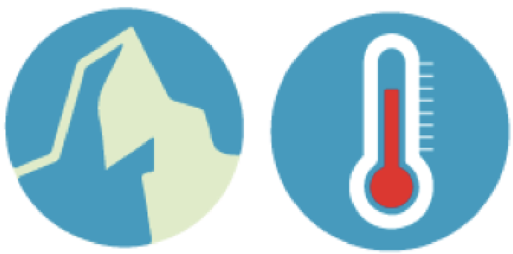

Figure 7.11. Environmental Factors that Influence Water Losses

concentrate the blood (i.e., hemoconcentration), which increases oxygen content and may reduce acute mountain sickness symptoms, like pulmonary and cerebral edema. In lowlanders exposed to moderate altitude (> 2,500 m), hypoxia rapidly initiates diuresis that continues for several days, at a rate that decreases total body water and plasma volume in proportion to the elevation of ascent. Fluid losses during cold exposure are also commonly thought to result from cold-induced diuresis. Cold-induced diuresis (CID) is well studied and is a "normal" physiological response to body cooling, but there is little relationship between the magnitude of water losses, or its effect on hemoconcentration. Another excretory junction is the skin. Water loss through the skin occurs via insensible diffusion and secreted sweat. For the average adult, loss of water by insensible diffusion is approximately 450 mL/day. During heat stress, eccrine sweat glands secrete sweat with latent heat onto the skin surface, which cools the body when water evaporates from the sweat. In hot weather, sweat evaporation provides the primary avenue of heat loss to defending the body's core temperature.

When a gram of sweat water is vaporized at 30°C, 2.43 kJ (0.58 kcal) of heat becomes kinetic energy For persons living in hot climates, **daily sweat losses** can exceed several liters. The environmental factors that modify climate-related sweat losses include clothing worn, ambient temperature, humidity, air motion, and solar load. Physical activity generally has a greater effect on respiratory water loss than do the environmental factors described above. For active persons living in temperate climates at sea level, exercise increases respiratory water losses by about 500 to 600 mL/day. Breathing hot, dry air during intense physical exercise can increase **respiratory water losses** by an additional 120 to 300 mL/day, and breathing cold (−20°C), dry air at rest, by approximately 5 mL/hour, or 340 mL/day. The amount of **respiratory water loss** via evaporation within the lungs is dependent on both the ventilatory volume and water vapor pressure gradient. Water vapor pressure is modified by the ambient temperature, humidity, and barometric pressure. High altitude alone can also increase respiratory water losses by approximately 200 mL/day above the usual baseline of 250 mL/day.

7.3 Homework 1

Homework • Answered

Water balance is maintained (in part) by this hormone that is produced in the pituitary gland.

- A rennin
- B aldosterone
- C anti-diuretic hormone
- D angiotensin

Answered - Correct!

1 attempt left Retry

7.3 Homework 2

Homework • Answered

What does angiotensin do?

- A Vasoconstriction of blood flow
- B Stimulates ADH release from pituitary
- C Reduces permeability of intestinal tract
- D Both A and B

Answered - Correct!

1 attempt left Retry

7.3 Homework 3

Homework • Answered

Which of the following factors does not increase urinary water losses?

A high altitude

B high protein intake

C cold temperature

D hot temperature

Explanation

Correct, URINARY water losses are not changed by hotter temperature - only skin losses are increased

Answered - Correct! No attempts left

7.4 Water Functions

Water comprises the majority of the total human body mass and is present in every single cell. Water is needed throughout the body for numerous biological functions that are critical for cell structure, homeostasis, and all cellular catalytic activities. The functional roles that water plays are a product of its solvent and protective capabilities.

Water makes up approximately 85% of human blood, 75% of muscle and brain, and around 20% of bone. Glycogen within the **muscle sarcoplasm** is stored with water, so that the lean tissues are much higher in fluid than fatty tissues, which are typically below 20% water. Muscle tissue is 70-75% water but is highly variable depending on factors that affect lean mass composition such as stored nutrients, hydration status and gender. The skeletal tissue is higher in water than bone overall, but the organic matrix portion of the bone has a very high water holding capacity comparable to lean tissue mass.

Throughout the body tissues, water acts as a lubricant, cushion, buffer, and the main ingredient in every body fluid including mucous, saliva, amniotic fluids, semen and others. Water is a solvent for nutrient absorption and transport as well as a medium for cellular biochemical reactions. Water in the cytoplasm also removes cellular waste including metabolic byproducts, like urea and creatinine. Water traveling through the lymphatic system collects waste and transports it across capillary spaces to the kidneys for removal.

Water has unique physical properties (e.g., high specific heat) that allow it to absorb metabolic heat within the body, lending to its role in temperature regulation. As body temperature increases, a series of reactions lead to blood vessel dilation and increased blood flow to the peripheral skin. Water moves across the dermis and releases heat as vapor into the air, thereby cooling the blood and core body temperature.

7.4 Homework 1

Homework • Answered

Which of the two are *not* functions of water?

Multiple answers: You can select more than one option

- (selected) **A** metabolism co-enzyme
- **B** primary chemical constituent of body
- **C** collects and removes cellular waste
- **D** cushions joints and organs
- **E** absorbs metabolic heat
- (selected) **F** chemical hydrolysis
- **G** strengthens bone proteins by re-mineralization
- **H** solvent for traveling nutrients
- **I** medium for cellular biochemical reactions

Hint

Try Again

Answered - Sorry, you didn't select **ALL** the correct answers.

No attempts left

Show Correct Answer

7.5 Hydration Status Measures

Imbalances in water intake and water losses have a number of adverse physiologic effects that can be measured clinically. **Thirst** is the primary clinical measure of dehydration, as the desire to drink is triggered by physiological cues in a body water deficit as low as 2%. The perceptible feedback mechanism stimulating water intake is initiated in the hypothalamus in response to inadequate body water. Various scales have been developed to quantify thirst by rating the sensation of, for example, dry mouth or dry throat. However, the most practical and commonly used approach in animal and human studies has been to document the volume of *ad libitum* (voluntary) drinking as a surrogate measurement of thirst.

If water is not available for several hours, water loss is apportioned between the intracellular and extracellular spaces, with nearly three-quarters devoted to the muscles and skin and the other 25% split between the viscera and bone. **Dehydration** compromises homeostasis during perturbations such as sickness, infection, trauma, physical exercise and environmental exposure. Dehydration can, for instance, enhance a **fever**—by mediating production and secretion of angiotensin II, for water conservation, and in turn, cellular cytokines, such as interleukin-1. Heat stress from exercise, unlike the set-point temperature increase in fever, increases core temperature proportionally to the metabolic rate, when the body is dehydrated as little as 1% percent of body weight, with a magnitude of core temperature elevation ranging from 0.1°C to 0.23°C for every percent body weight lost. The core temperature elevation from dehydration is generally greater during exercise in hot, compared with temperate climates as it occurs from reductions in local sweat capacity and skin blood flow responses.

Dehydration also increases cardiovascular strain. Dehydration increases **resting heart rate** when standing or lying down in temperate conditions. In addition, dehydration makes it more difficult to maintain blood pressure during exposure to various perturbations, which induces fainting in susceptible individuals. The effects of dehydration on cardiovascular responses to physical activity also include increased heart rate in proportion to the magnitude of water deficit. Dehydration-mediated hypovolemia reduces central venous pressure and cardiac filling and requires a compensatory increase in heart rate. During submaximal exercise with little heat strain, dehydration elicits an increase in heart rate and a decrease in stroke volume, and usually no change in cardiac output relative to dehydration levels. Heat stress and dehydration together, however, increase cardiovascular strain and result in a reduced cardiac output.

For obvious reasons, experimental data is not available on the effects of dehydration with **death** as an outcome in humans. Humans can lose 10% of body weight as water with little-increased risk of death unless dehydration is accompanied by other severe stressors like illness, extreme heat, or vigorous exercise. Beyond 10%, death is a serious risk as body temperature can rise rapidly and lead to death at temperatures of 107°F.

Common clinical symptoms associated with chronic low fluid intake include increased likelihood of gallstones, kidney stones, and urinary tract infections. **Acute measures of hydration status** typically span 24- to 48-hour periods and usually measure changes in body weight, serum solute concentrations, and urine volume.

Body weight changes are frequently used to estimate sweating rates and therefore changes in total body water. This approach is usually used to estimate changes over a relatively short duration when food and fluid intakes and excretions are carefully controlled. The validity of this estimate depends upon body weight measurements not being confounded by other non-fluid factors that can influence body weight changes, changes in respiratory water loss, metabolic mass loss, and water trapped perspiration in clothing. If proper controls are made, body weight changes can provide a more sensitive estimate of total body water turnover than repeat measurements by dilution methods.

Total body water (TBW) is accurately determined by dilution of a variety of indicators and repeated measurements to assess total body water changes. TBW can also be calculated based upon body composition information and estimated indirectly using bioelectric impedance analysis. (BIA) has recently gained attention because it is simple to use and allows rapid, inexpensive and noninvasive estimates of TBW. Absolute values derived from this technique correlate well with direct TBW values obtained by isotope dilution, but may not have sufficient accuracy to validly detect moderate dehydration.

Plasma osmolality provides a good marker for dehydration status when water loss is greater than solute loss. When solute and water are lost proportionately, such as with diarrhea or vomiting, osmolality remains constant and vasopressin release is blunted. If solutes are concentrated in the ECF, the renin-angiotensin-aldosterone is activated to increase sodium and thus water retention.

Figure 7.13. Urinary Analysis- A Common Method to Assess Hydration Status

Urine volume is often used as an indicator of hydration status. Well-hydrated individuals have urine outputs of approximately 100 mL/hour. If urine output falls to less than 30 mL/hour for extended periods with an average diet, the person is probably dehydrated. Urine **color** darkens because the solute load is concentrated, thus, urine color has long been used as an indicator of hydration status. However, diet, medications and vitamin use can also affect urine color, so no precise correlation can exist between urine color and hydration level. Still, urine color can provide a crude educational tool for hydration status as evidenced by, among other things, urine color charts for athletes.

Blood urea nitrogen (BUN) is primarily considered an indicator of kidney function, but it is also used as an indicator of dehydration in clinical settings. The pattern of high BUN (normal range 8 to 25 mg/dL) and otherwise normal renal function is considered an indicator of hypovolemia. However, since BUN is also directly related to protein intake, other biochemical values, such as creatinine, must be considered in order to assess hydration.

In very unusual circumstances, **excess consumption** of hypotonic fluids accompanied by low sodium intake can lead to excess body water. This condition results in hyponatremia and subsequent cellular edema. Water intoxication or **hyper-hydration** induces a modest increase in plasma volume, and an increases urinary excretion proportionally to the volume consumed. Urinary output three to six times higher than the normal rate is probably indicative of hyper-hydration, or fluid excess.

7.5 Homework 1

Homework • Answered

Which of the following measures of hydration status is the most sensitive?

- ○ **A** bioelectrical impedance
- ○ **B** thirst
- ○ **C** urine color
- ◉ **D** urine volume

Answered - Correct!

No attempts left

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