

# Temperature Regulation

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# OBJECTIVES

- \* 1. To discuss the importance of temperature regulation
- \* 2. To discuss the means of heat loss and generation
- \* 3. To discuss temperature regulation and thermoreceptor
- \* 4. To discuss concept of fever, hyperthermia and hypothermia

- \* Core temperature refers to temperature of deep structures in the body unlike the skin temperature
- \* The core temperature is well closely regulated compared to the skin temperature
- \* Temperature varies with parts of the body, time of the day, state of health
- \* Temperature is lower in the extremities compared to the trunk. Scrotal temperature is around 32 degree celsius

- Core temperature is assessed using oral or rectal temperature
- \* Normal morning oral temperature varies between 36.3 -37.1 degree celsius
- \* Oral temperature is 0.5 degree celsius lesser than rectal temperature
- \* Oral temperature may be affected by mouth breathing, temperature of food and smoking.
- \* Human core temperature also undergoes circadian fluctuation. Lowest at about 6.00am and highest in the evenings

- The body temperature is well regulated in order to ensure normal enzymatic process
- \* Extremes of temperature adversely affect normal cellular processes, thereby leading to ill-health.
- \* Core temperature is kept constant within  $\pm 0.6$  degree celsius or  $\pm 1$  degree F
- \* Heat production and heat loss is well balanced
- \* Heat production < heat loss= Temperature reduces
- \* Heat production > heat loss= Temperature increases

# Heat Production

- \* Basal Metabolism
- \* Muscle activity: Muscle contraction and shivering
- \* Extra metabolism: Effects of hormones such as thyroxine, growth hormone, testosterone, epinephrine, norepinephrine
- \* Thermogenic effect of food
- \* Sympathetic stimulation
- \* Brown fat metabolism

- \* Neonates and animals have large amount brown fat compared to adults.
- \* Brown fat metabolism plays a major role in heat production and regulation in newly born and animals compared to adult man.
- \* Brown fat which have many mitochondria compared to other tissues, hence there is increased uncoupling of phosphorylation which generates heat.

# Methods of Heat Loss

- \* Conduction: 3%
- \* Radiation: 60%
- \* Convection: 15%
- \* Evaporation: 22%
- \* Feaces
- \* Urine

Heat is loss through feaces and urine, although quite negligible

Vaporization of 1g of water removes 0.6kcal of heat.



# Thermo-receptors

- \* There are connections between the various thermal receptors located in the superficial and deep structures and the brain

# Superficial and Deep Thermo- receptors

- \* Skin
- \* Visceral organs
- \* Great veins of the abdomen and thorax
- \* Spinal cord

# Central Temperature Regulators

- \* Anterior Hypothalamus: Preoptic nuclei
- \* Posterior Hypothalamus
  
- \* The Anterior Hypothalamus contain more warm receptors than cold receptors
  
- \* The Posterior Hypothalamus contains more cold receptors than warm receptors

# Concept of Temperature Set Point

- \* The critical body core temperature is about  $37.1^{\circ}\text{C}$  ( $98.8^{\circ}\text{F}$ )
- \* At temperatures above this level, the rate of heat loss is greater than that of heat production, so the body temperature falls and approaches the  $37.1^{\circ}\text{C}$  level.
- \* At temperatures below this level, the rate of heat production is greater than that of heat loss, so the body temperature rises and again approaches the  $37.1^{\circ}\text{C}$  level.
- \* This crucial temperature level is called the “set-point” of the temperature control mechanism.
- \* That is, all the temperature control mechanisms continually attempt to bring the body temperature back to this set-point level.

# Mechanisms Activated by Cold

- \* Increased Heat Production
- \* Vasoconstriction of cutaneous vessels
- \* Shivering and Muscle contraction
- \* Hunger
- \* Decrease sweating
- \* Increased secretion of epinephrine and norepinephrine
- \* Curling up
- \* Behavioral adjustment
- \* Horripilation
- \* Decreased Heat Loss

# Mechanisms Activated by Heat

- \* Increased heat loss
- \* Decreased heat production
- \* Cutaneous vasodilation
- \* Increased sweating
- \* Increased respiration
- \* Anorexia
- \* Behavioral adjustment
- \* Apathy and Inertia

# FEVER

- \* Fever is defined as temperature above normal range
- \* Fever could be caused by infections(viral, bacteria, protozoan or fungal), CNS lesions such as stroke, tumours affecting the temperature regulating centre of the brain
- \* Fever is mediated by endogeneous pyrogens
- \* Endogeneous pyrogens induces formation of Prostaglandin E2 which acts on hypothalamus to produce fever
- \* Fever may be protective in certain infection by enhancing antibody formation and inhibition of microbial growth
- \* ***Endogenous Pyrogens: IL-1 $\beta$ , IL-6 , TNF- $\alpha$ , IFN- $\beta$ , IFN- $\gamma$***

**CHILLS:** The set-point of the hypothalamus is changed from the normal level to higher than normal in the presence of pyrogenic substances. This makes the blood temperature to be less than the set point of the hypothalamus.

- \* The hypothalamus therefore stimulates mechanisms such as shivering that lead to heat generation so that the temperature can reach the new set point. During this period, the person experiences chills and feels extremely cold, even though his or her body temperature may already be above normal.
- \* Also, the skin becomes cold because of vasoconstriction. Chills can continue until the body temperature reaches the new hypothalamic set-point



\* ***Crisis or Flush:*** If the factor that causes the high temperature is removed, the temperature set-point of the hypothalamus will reduce. This causes intense sweating and cutaneous vessels vasodilation in order to dissipate heat. This usually manifest as profuse sweating.

Bacterial Products e.g Lipopolysaccharide (LPS)

Monocytes, Macrophages, Kupffers cells

Preoptic Area of Hypothalamus

Raise Temperature Set point

FEVER

# Hyperthermia

Although most individuals with elevated body temperature have fever. There are circumstances where elevated temperature do not represent fever but hyperthermia.

- \* Hyperthermia is characterized by an uncontrolled increase in body temperature that exceeds the body's ability to lose heat. The setting of the hypothalamic thermoregulatory center is unchanged. In contrast to fever in infections, hyperthermia does not involve pyrogenic molecules.
- \* Exogenous heat exposure and endogenous heat production are two mechanisms by which hyperthermia can result in dangerously high internal temperatures. Excessive heat production can easily cause hyperthermia despite physiologic and behavioral control of body temperature.
- \* For example, work or exercise in hot environments can produce heat faster than peripheral mechanisms can lose it.

# Causes of Hyperthermia

- \* Thyrotoxicosis
- \* Heatstroke
- \* Drugs e.g anticholinergics, diuretic
- \* Hypothalamic injury

# Heatstroke

Heatstroke is a cause of hyperthermia. The upper limit of air temperature that one can stand depends almost entirely on whether the air is dry or wet.

- \* If the air is dry and sufficient convection air currents are flowing to promote rapid evaporation from the body, a person can withstand several hours of air temperature at 130°F
- \* When the body temperature rises beyond a critical temperature, into the range of 105° to 108°F, the person is likely to develop *heatstroke*.
- \* *Heat stroke* in association with a warm environment may be categorized as exertional or non-exertional.
- \* *Exertional heat stroke* typically occurs in individuals exercising at elevated ambient temperatures and/or humidities.
- \* *Non-exertional heat stroke* typically occurs in either very young or elderly individuals, particularly during heat waves.
- \* The elderly, the bedridden, persons taking anticholinergic drugs or diuretics, and individuals confined to poorly ventilated and non-air-conditioned environments are most susceptible

# Features of Heatstroke

The symptoms include dizziness, abdominal distress vomiting, sometimes delirium, cerebral haemorrhage and eventually loss of consciousness if the body temperature is not soon decreased.

These symptoms are often exacerbated by a degree of *circulatory shock* brought on by excessive loss of fluid and electrolytes in the sweat.

The hyperpyrexia itself is also exceedingly damaging to the body tissues, especially the brain, and is responsible for many of the effects

# Exposure to Extreme Cold/Hypothermia

If the body temperature falls below a 85°F, the ability of the hypothalamus regulate temperature is lost

It is greatly impaired even when the body temperature falls below 94°F

This is partly due to depression in the rate of chemical heat production in each cell.

Also, sleepiness develops (later followed by coma), which depresses the activity of the central nervous system heat control mechanisms and prevents shivering

Some other features of hypothermia are bradycardia, hypotension, hypoventilation and reduced urinary output

# Frostbite

Exposure to extreme cold temperature below  $0^{\circ}\text{C}$  may cause surfaces of the skin to freeze. This is known as frostbite

- \* This may lead to formation of ice within the cells, causing cellular damage and permanent circulatory impairment.
- \* Once the vascular endothelium is damaged, stasis progresses rapidly to microvascular thrombosis.
- \* Repeated freezing and thawing of the ice may cause local tissue damage and gangrene of tissues especially the digits, nose tip and ear lobes