TEMPERATURE MEASUREMENT

Body temperature is one of the oldest known indicators of the general well-being of a person. Two basic types of temperature measurements are Systematic temperature measurement and Skin surface measurement.

Systematic Temperature:

It is the temperature of the internal regions of the body. This temperature is maintained through a carefully controlled balance between the heat generated by the active tissues of the body and heat last by the body to the environment. Measurements of systematic temperature are accomplished by temperature sensing devices placed in mouth, under the armpits or in the rectum.

Systematic temperature most accurately measured at the tympanic membrane in the ear. Exercise may cause a temporary rise in the temperature about (0.5 to 2^o C i.e 0.9 to 3.6^oF) the systematic temperature is not affected by the ambient temperature even for low as ($-18^oC(0^oF)$) rise to over ($38^oC(100^oF)$).

Temperature control of the body is located deep within the brain. Warm, cooling, ambient temperature production of perspiration due to secretion of the sweat glands and increase circulation of blood. The only deviation from normal temperature control is a rise in temperature called fever.

At the beginning of a fever the skin is often pale, dry and shivering usually takes place then the skin and muscles react to the coolness. At the conclusion of the fever, as the body temperature is lowered to normal, increased sweating body heat is eliminated.

Measurement of systematic body temperature:

The mercury thermometer is still the standard method or measurement. These devices are inexpensive, easy to use and sufficiently accurate. Two types of electronic temperature sensing devices are found in bio-medical applications.

Thermocouple:

A junction of two dissimilar metals that produces as output voltage nearly proportional to the temperature at that junction with respect to a reference junction.

Thermistor:

A semiconductor element whose resistance varies with temperature. Thermistors are used more frequently than thermocouples because of greater sensitivity. Thermistors are variable resistance devices formed into disks, beads, rods or other desired shapes. Thermistors are manufactured from mixtures of various elements such as nickel, copper, magnesium, manganese, cobalt, titanium and aluminium.

This mixture is compressed into shape with high temperature into a solid mass. It's results resistor with a large temperature coefficient. Unfortunately, the relationship between resistance change and temperature change is non-linear. Therefore, the resistance R_{t1} of thermistor at temperature T_1 determined by the equation.

$$R_{t1} = R_{t0}\, e^{\beta}\, (1/T_1 - 1/T_0)$$

Where R_{t1} – resistance at temperature T_1

R_{t0} – resistance at reference temperature T_0

e – base of natural algorithms

β – temperature coefficient (range of 3000-4000)

T_1 – temperature at which measurement is taken

T_0 – reference temperature (degree kelvin)

Selection of thermister probe

1. Physical configuration of probe
2. Sensitivity of the device
3. Absolute temperature range over which the thermister is designed to operate
4. Resistance range probe

Skin Temperature:

Surface or skin temperature is also result of a balance. But the balance between the heat supplied by blood circulation and cooling by conduction, radiation, convection and evaporation.

Skin temperature measurement:

Skin temperature is a function of surface circulation, environmental temperature, air circulation from which the measurement taken and perspiration. Systematic temperature remaining very constant throughout the body. But skin temperature can vary several degrees from one point to another.

Skin temperature measurements are frequently made by using small, flat thermistor probes. The human skin has been found to be an almost perfect emitter of infrared radiation. Such a device called an infrared thermometer.

RESPIRATORY RATE MEASUREMENT

The exchange of gases in any biological process is termed as respiration. In the human body, the respiration can be classified as,

- Internal Respiration: The exchange of gases between the blood stream and nearby cells inside the body is called internal respiration.
- External Respiration: The exchange of gases between the lungs and blood stream inside the body is called external respiration.

Breathing consists of two phases,

1. Inspiration – the process of taking in air
2. Expiration – the process of blowing out air

Boyle's Laws

It states that, at constant temperature, the volume of gas varies inversely with the pressure.

i.e., $P \propto \frac{1}{V}$ or $P \times V = \text{constant}$

Here, if volume is increased, pressure falls down, when the volume is decreased the pressure increases.

Charle's Law

It states that, at constant pressure, the volume of gas is directly proportional to the absolute temperature.

i.e., $V \propto T$ or $V \times T = \text{constant}$

Henry's Law

It states that, if the temperature is constant the quantity of a gas that goes into a solution is directly proportional to the partial pressure of that gas.

Dalton's Law

It states that, the total pressure exerted by a mixture of gases equal to the sum of the partial pressure of various gases.

$$P_T = P_1 + P_2 + \dots + P_n$$

Instrumentation for respiration measurement:

The mechanics of breathing can be derived from measurement of lung volumes at various levels and conditions of breathing, pressure within the lungs and the thorax with respect to outside air pressure and instantaneous air flow.

Spirometer:

The mostly widely used laboratory instrument for respiratory volume measurements is the spirometer. It is possible to determine all lung volumes and capacities by measuring the amount of gas inspired or expired under a set of conditions or during a specified time interval using a spirometer. Hence it is used to measure the,

- Vital capacities
- Forced expiratory volumes can be performed on a spirometer

The spirometer consists of a movable bell inverted over a chamber of water. The bell contains air above the water line which is used for breathing. The inverted bell is counterbalanced by a weight to ensure that the air inside the bell remains at atmospheric pressure.

Now the amount of air inside the inverted bell above the water line is proportional to the height of the bell above the water line. The height of the bell above the water line can be directly calibrated to the volume of the air breathed in and out. A pen that can write on a drum recorder can be attached to the counter balancing mechanism to trace the breathing pattern of the patient.

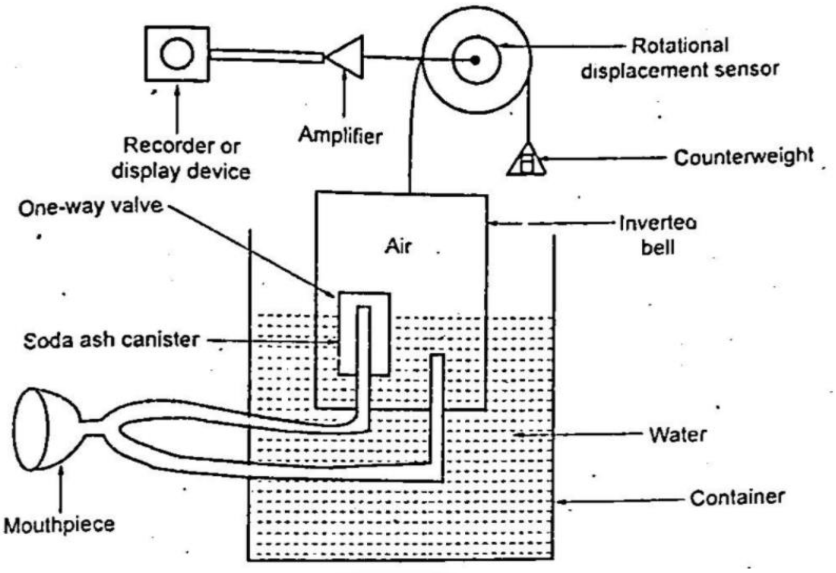

Fig: Spirometer

However, a spirometer cannot measure volumes and capacities which requires the measurements of the gas that cannot be expelled from the lungs. Such measurement includes the measurement of

- Residual volume
- Functional residual capacity and
- Total lung capacity

Measurement of Residual volume:

From the spirogram and the outputs of some of the other requirements, all the lung volumes and capacities can be determined except those that require measurement of the air remaining in the lungs and airways after maximum expiration.

The closed-circuit technique:

The technique involves breathing from a spirometer which has a known volume of air with a fixed concentration of helium gas under the inverted bell. The patient is made to breathe this air for a considerable period so that a complete mixing of gas in the spirometer and the lungs can be assured.

Now the concentration of helium gas in spirometer is ascertained with the help of a gas analyser. The concentration of helium gas in spirometer is a measure of the residual volume (RV).

The nitrogen washed out technique:

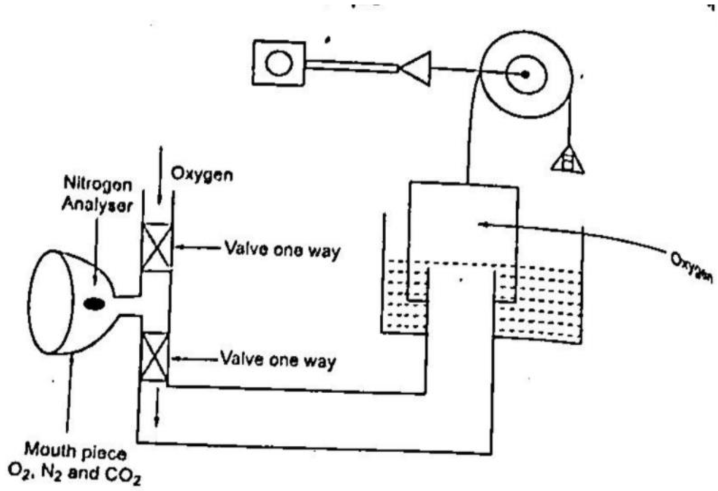

Fig: Nitrogen washed out technique

This technique involves the inspiration of pure oxygen and expiration into a spirometer which has oxygen in the inverted bell. During breathing, we have almost 78% nitrogen remaining in our lungs. Hence, on expiration, a certain amount of nitrogen will wash out from the lungs which can be measured with expired breath.

Intra-alveolar and Intra-thoracic pressure measurements:

Plenthysmograph is an airtight box in which the patient is made to sit. The patient breathes air from within the airtight box through a tube provided inside the box. The tube has a shutter to close the tube and a pressure transducer to measure the air pressure in the breathing tube.

Another pressure transducer is provided in the airtight box to measure the pressure in the box. Now when the patient and the box are considered, then the total air in them is the sum of the air inside the box (V_b) and the air in the lungs of the patient (V_p) i.e., intra-thoracic volume.

$$V_{total} = V_b + V_p$$

On small change, we get

$$\Delta(V_{total}) = \Delta(V_b) + \Delta(V_p)$$

But $\Delta(V_{total}) = 0$ as airbox is airtight

$$\Delta(V_b) = -\Delta(V_p) \text{ ------ (1)}$$

As per Boyle's law, we have

$$P_p V_p = \text{constant}$$

Here P_p = inter-thoracic pressure

Or $$\Delta P_p = -\Delta V_p \text{ ------ (2)}$$

From equations 1 and 2, we have

$$\Delta P_p = \Delta (V_p)$$

The above relation shows that during expiration when pressure in the lungs is high, then air volume of the box increases while it decreases when the patient inspires.

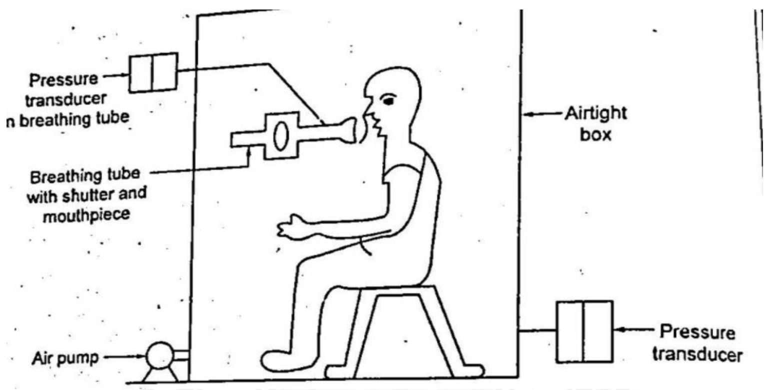

Fig: Body plenthysmograph

Airway resistance measurements:

The airway resistance is determined by simultaneously measuring intra-alveolar pressure and airflow in the body plenthysmograph. The airflow resistance can be given by the relation of

$$R = \frac{P_{ia} - P_{atm}}{f}$$

Where, R=airway resistance

P_{ia} = intra-alveolar pressure

P_{atm} = atmospheric pressure

f = airflow

PULSE MEASUREMENT

When heart muscle contracts, blood is ejected from the ventricles and a pulse of pressure is transmitted through the circulatory system. This pulse can be measured at various points. We can sense the pulse by placing our fingertip over the radial artery in the wrist. This pulse travels at the speed of 5 to 15 meters/second. Photoelectric method is commonly employed to measure the pulse. Photoelectric method consists of two types, namely Transmittance method and Reflectance method.

Transmittance Method:

LED and photoresistor are used in this method. There are mounted in an enclosure that fits over the tip of the finger. Light is produced by the LED. The same light is passed through the finger.

For each heart pulse, blood is forced to the extremities and the amount of blood in the finger is increased. So optical density is changed. Then the light transmitted through the finger is decreased. This light is received by the photoresistor.

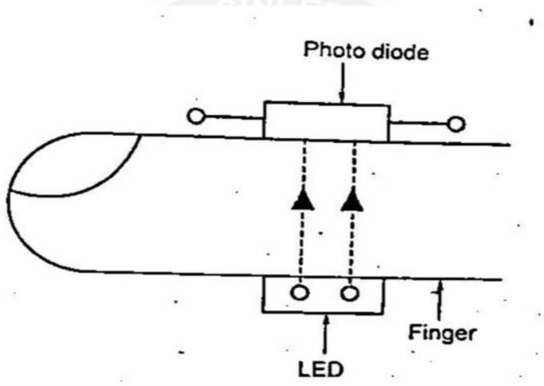

Fig: Transmittance method

This photoresistor is connected with the part of voltage divider circuit. The voltage produced by this circuit is directly proportional to the amount of blood flow in the finger. The output is recorded by using strip chart recorder.

Reflectance Method

In reflectance method, LED is placed adjacent to the photoresistor. LED emits the light, and this light is reflected from the skin and the tissue falls on the photoresistor. The reflected light varies depending upon the blood flow in the finger.

The photoresistor is connected as a part of the voltage divider circuit. The output obtained is directly proportional to the amount of blood in the finger. The output can be recorded using strip chart recorder.

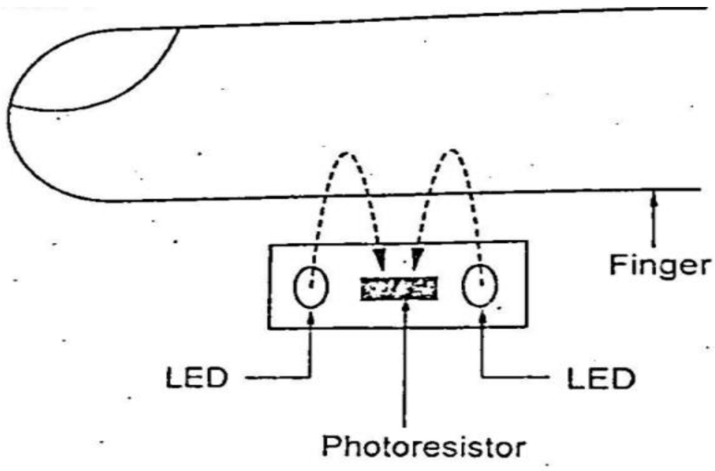

Fig: Reflectance method