

## **HIGH ALTITUDE**

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### **Introduction:**

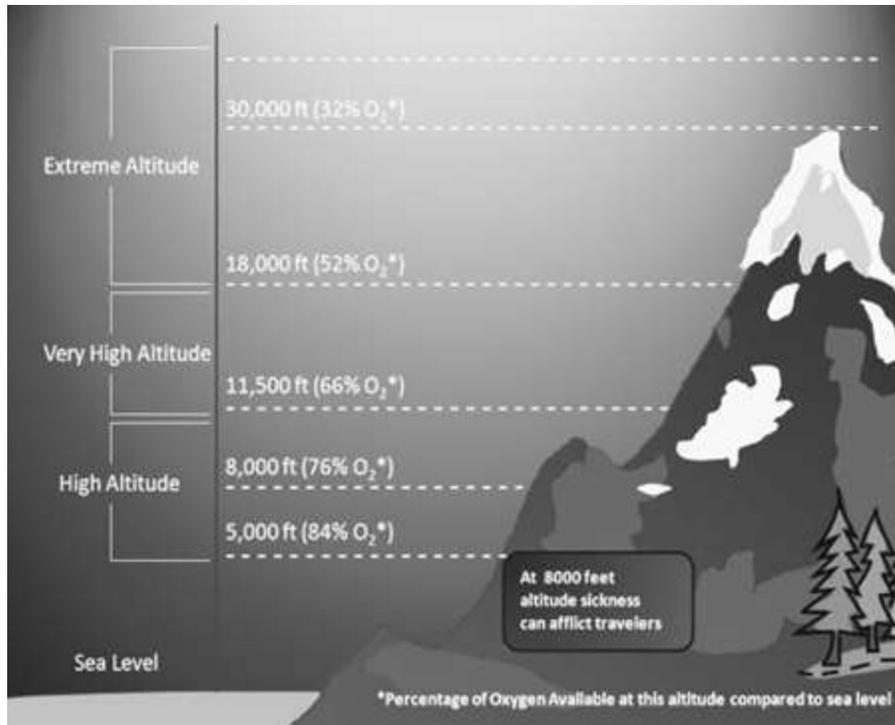
Any altitude above 8000 feet from sea level is termed as high altitude. People can ascend upto this level due to lack of any adverse effect. At high altitudes, the barometric pressure is very low. Whatever it may be, the amount of oxygen available in the atmosphere is equal as it is at the sea level also. Because of low barometric pressure, partial pressure of gases especially oxygen proportionally reduces. It leads to the occurrence of hypoxia. The carbon dioxide in high altitude very negligible and it doesn't raise any adverse effects. The different altitudes are given table.

### *Different altitudes*

<i>Altitude</i>	<i>Feet</i>	<i>Meters</i>
High altitude	8,000-13,000	2,500-4,000
Very high altitude	13,000-18,000	4,000-5,500
Extreme altitude	>18,000	>5,500

### **Different altitudes in schematic diagram**

### ***BAROMETRIC PRESSURE AND PARTIAL PRESSURE OF OXYGEN AT DIFFERENT ALTITUDES***



The barometric pressure reduces at different altitudes and accordingly the partial pressure of oxygen also reduces and leads to the occurrence of various effects on the body. Barometric pressure and partial pressure of oxygen at different altitudes and their general effects on the body are given in the below table.

**Barometric pressure, partial pressure of oxygen and common effects at different altitudes**

<i>Altitude (feet)</i>	<i>Barometric pressure (mm Hg)</i>	<i>Partial pressure of oxygen (mm Hg)</i>	<i>Common effects</i>
Sea level	760	159	-
5,000	600	132	No hypoxia
10,000	523	110	Mild symptoms of hypoxia start appearing
15,000	400	90	Moderate hypoxia develops with following symptoms: -Reduction in visual acuity -Effects on mental functions: -Improper judgment and -Feeling of over confidence
20,000	349	73	Severe hypoxia appears with cardiorespiratory symptoms

			such as –Increase in heart rate and cardiac output –Increase in respiratory rate and respiratory minute volume. This is the highest level for permanent inhabitants
25,000	250	62	This is the critical altitude for survival –Hypoxia becomes severe –Breathing oxygen becomes essential
29,628	235	49	This is the height of Mount Everest.
30,000	226	47	Symptoms become severe even with oxygen.
50,000	87	18	Hypoxia becomes more severe even with pure oxygen.

***CHANGES IN THE BODY AT HIGH ALTITUDE***

If a person is exposed to high altitude especially by severe ascent, the different systems in the body cannot cope with particularly lowered oxygen tension and the effects of hypoxia begin. A very few other factors of hypoxia lead to the occurrence of the changes in the functions of the body at high altitude. Many factors affecting the physiological functions at high altitude include-

- a) Expansion of gas
- b) Fall in atmospheric temperature
- c) Hypoxia
- d) Light rays

***EFFECTS OF HYPOXIA***

Acute and severe hypoxia results in occurrence of unconsciousness. Brain death happens without immediate treatment. Chronic hypoxia leads to the occurrence of different symptoms in the body.

***EFFECTS OF EXPANSION OF GASES ON THE BODY***

Volume of gases increases when the barometric pressure is reduced. So at high altitude, due to the decreased barometric pressure, volume of all gases increases in atmospheric air, as well as in the body.

At the sea level with atmospheric pressure of 760 mm Hg, if the volume of gas is 1 liter, at the height of 18,000 feet (where atmospheric pressure is 379 mm Hg), it becomes 2 liter. And it becomes 3 liter, at the height of 30,000 feet (where atmospheric pressure is 226 mm Hg).

Expansion of gases in GI tract causes painful distention of stomach and intestine. It is minimized by supporting the abdomen with a belt or by evacuation of the gases. Expansion of gases also destroys the alveoli.

During very rapid ascent from sea level to over 30,000 feet height, the gases evolve as bubbles, particularly nitrogen, resulting in decompression sickness.

### ***EFFECTS OF REDUCED ATMOSPHERIC TEMPERATURE***

Environmental temperature falls gradually at high altitudes. The temperature decreases to about 0°C at the height of 10,000 feet. It becomes -22°C at the height of 20,000 feet. At the altitude of 40,000 feet, the temperature falls to -44°C. Injury due to cold or frostbite occurs if the body is not adequately protected by warm clothing.

### ***EFFECTS OF LIGHT RAYS***

Skin exhibits susceptibility to the injury because of many harmful rays such as ultra violet rays of sunlight. Beyond this, the sun rays reflected by the snow may cause damage to the retina of eye, if it is not provided with protection particularly with suitable tinted glasses. The severity of all these effects is based on the speed at which one ascends to high altitude. The effects are comparatively milder or moderate particularly in slow ascent and severe in rapid ascent.

## **MOUNTAIN SICKNESS**

### ***DEFINITION***

Mountain sickness is a condition manifested by adverse effects of hypoxia especially at high altitude. It is generally observed in persons ascending to high altitude for the first time. It happens within a day in these persons before they get acclimatized to the altitude.

### ***SYMPTOMS***

In mountain sickness, the symptoms occur mostly in digestive system, cardiovascular system, respiratory system and nervous system.

#### ***Cardiovascular system***

Heart rate is enhanced

***Digestive system***

Loss of appetite, nausea and vomition happens due to the expansion of gases particularly in the GIT.

***Nervous system***

The symptoms of nervous system include depression, disorientation, fatigue, headache, irritability, lack of sleep and weakness. These symptoms are observed due to cerebral edema. Sudden exposure to hypoxia in high altitude leads to the occurrence of vasodilation in brain. The auto regulation mechanism of cerebral blood flow fails to cope with hypoxia. It results in the enhancement of capillary pressure and leakage of fluid from capillaries into the brain tissues.

***Respiratory System***

Pulmonary blood pressure enhances because of enhanced blood flow. Blood flow enhances due to hypoxia induced vaso dilatation. Enhanced pulmonary blood pressure leads to the occurrence of pulmonary edema which cause breathlessness.

***TREATMENT:***

The symptoms of mountain sickness are not observed particularly by breathing oxygen.

**ACCLIMATIZATION*****DEFINITION***

Acclimatization is related to the adaptations or the adjustments by the body in high altitude. If a person is staying at high altitudes for several days to several weeks, that person obtains adapted or adjusted to low oxygen tension so that hypoxia leads to occurrence of lesser and lesser effects on the body. It makes the person to ascend further also.

***Changes during acclimatization:***

The changes during acclimatization assist the body to withstand against the adverse effects of hypoxia particularly at high altitude. Following changes happens especially in the body during acclimatization.

***1.Changes in the blood***

Particularly during acclimatization, the RBC count enhances and packed cell volume(PCV) increases from the normal value of 45 % to about 59 %. The hemoglobin content in the raises approximately from 15 to 20 g%. So the oxygen carrying capacity of the blood is also enhanced. So, more oxygen can be transported to the tissues despite hypoxia. Enhancement in packed cell volume (PCV) and hemoglobin (Hb) content occur because of the actions of erythropoietin actions. Enhancement in RBC count, PCV and Hb content is because of erythropoietin that is released particularly from juxtaglomerular apparatus (JGP) of kidney. Erythropoietin activates

redbone marrow also. So, the RBC count enhances. Thus, the oxygen carrying capacity of blood is regulated by an enhancement in RBC count and Hb content in blood.

### ***Changes in Cardiovascular System***

Overall activity of cardiovascular system is enhanced especially in high altitude. There is an enhancement in rate and force of contraction of heart and cardiac output also. Hypoxia induced vasodilation enhances the vascularity in the body. So, the blood flow to the vital organs namely heart, brain and muscles etc.

### **Respiratory system**

#### ***i. Diffusing capacity of gases***

Because of the enhanced pulmonary blood flow and enhanced ventilation, the diffusing capacity of the gases enhances particularly in the alveoli. It enables more diffusion of oxygen in blood also.

#### ***ii. Pulmonary ventilation***

Pulmonary ventilation increases up to 65%. This is the immediate compensation for hypoxia in high altitude and this alone helps the person to ascend several thousand feet. Increase in pulmonary ventilation is due to the stimulation of chemoreceptors.

#### ***ii. Pulmonary hypertension***

Increased cardiac output increases the pulmonary blood flow that leads to pulmonary hypertension. It is very common even in persons acclimatized to high altitude. In some of these persons, pulmonary hypertension is associated with right ventricular hypertrophy.

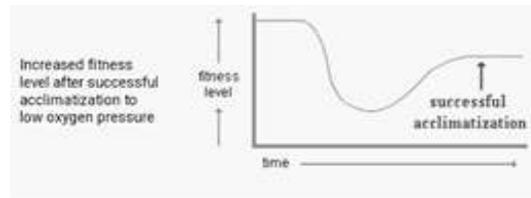
### ***Changes in tissues***

Both in human beings and animals living at high altitudes permanently, the cellular oxidative enzymes participated in many metabolic reactions are more than in the inhabitants particularly at the sea level. Even if a sea level inhabitant resides at high altitude for certain period, the amount of oxidative enzymes is not enhanced.

Then the enhancement in the amount of oxidative enzymes happens only in fully acclimatized persons. An enhancement in the number of mitochondria is also seen in these persons.

### **Human Biological Adaptability: *Adapting to High Altitude***

Here we explain the human Biological adaptability in the form of graphs taking person fitness as example.



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