



Ergonomics

Environmental Risk Factors –Altitude

Introduction to Altitude

Working at high altitudes can put you at risk for acute altitude sickness if you do not take precautions to acclimatize yourself to the new altitude slowly. Altitude is defined on the following scale (1):

Altitude Category	Height
High	8,000 - 12,000 feet (2,438 – 3,658 meters)
Very High	12,000 - 18,000 feet (3,658 – 5,487 meters)
Extreme	18,000+ feet (5,500+ meters)

Altitude sickness occurs because there are fewer oxygen molecules available to the body at altitude due to the decreasing air pressure as you ascend in altitude. There are no specific factors such as age, sex, or physical condition that causes one person to be more susceptible to altitude sickness than someone else (1). Some people get it, and some people do not. Most people can safely go up to 8,000 feet (2,438 meters) with few, if any, symptoms of altitude sickness (1). However, if you haven't been to high altitude before, it is important to be cautious. If you have been to high altitude before with no problems, you can probably return to that altitude without problems as long as you take the proper precautions to acclimatize yourself.

Environmental Risk Factors

Heat Stress
Cold Stress
Altitude

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It doesn't matter if you are....

MALE or *Female*

Young or **OLD**

A Couch Potato or **A Marathon Runner**

....altitude sickness doesn't discriminate.

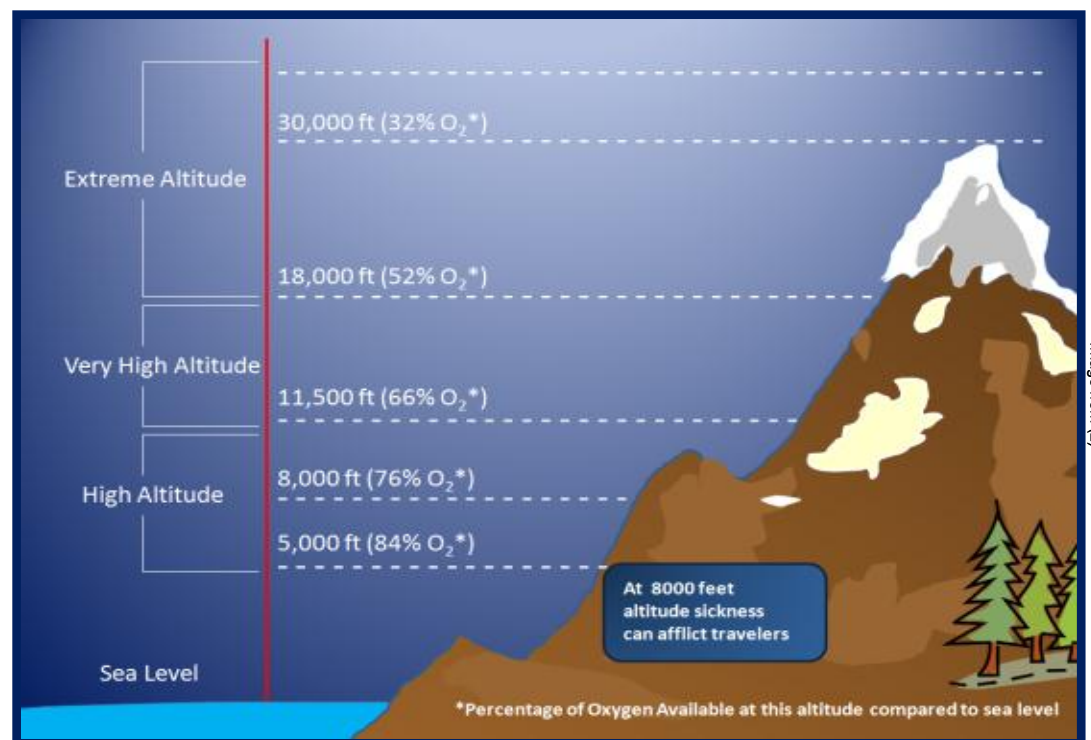


Image from (2)

What is Altitude Sickness?

Altitude sickness is common at high altitudes. At elevations over 10,000 feet (3,048 meters), 75% of people will have mild symptoms (1). Symptoms begin 12 - 24 hours after arrival at altitude and most subside within 36 to 48 hours (1,3). Altitude sicknesses include a spectrum from acute altitude sickness to high-altitude pulmonary edema (HAPE) to high altitude cerebral edema (HACE). The exact mechanisms of altitude sickness are not completely understood, but the symptoms are thought to be due to mild swelling of brain and lung tissue in response to the stress of decreased oxygen. If this swelling progresses far enough, significant brain and lung dysfunction occurs.

Altitude Sickness	Signs /Symptoms (1,3,6)	Treatment (1,3,6)
Acute Altitude Sickness (Mild)	<ul style="list-style-type: none"> • Lack/loss of appetite • Nausea • Vomiting • Dizziness or lightheadedness • Tingling in fingers, nose and face • Shortness of breath with exertion • Persistently rapid pulse • Fatigue • Malaise • Swollen hands, feet and face • Reduced urine output 	<ul style="list-style-type: none"> • Descend to lower altitude • Pain medications for headache
Acute Altitude Sickness (Moderate)	<ul style="list-style-type: none"> • Severe headache that is not relieved by medication • Nausea and vomiting • Increasing weakness and fatigue, • Shortness of breath • Decreased coordination (ataxia). 	<ul style="list-style-type: none"> • Immediately descend to lower altitude • Seek medical attention
Acute Altitude Sickness (Severe)	<ul style="list-style-type: none"> • Shortness of breath at rest • Inability to walk • Decreasing mental status • Fluid buildup in the lungs 	<ul style="list-style-type: none"> • Immediately descend to lower altitude • Immediately seek medical attention
High Altitude Pulmonary Edema (HAPE) <i>Results from fluid buildup in the lungs.</i>	<ul style="list-style-type: none"> • Persistent dry cough • Fever • Shortness of breath at rest • Blue face, lips, fingernails (cyanosis) 	<ul style="list-style-type: none"> • Immediately descend to lower altitude • Immediately seek medical attention
High Altitude Cerebral Edema (HACE) <i>Results from swelling of brain tissue from fluid leakage.</i>	<ul style="list-style-type: none"> • Headache that is not relieved by medication • Loss of coordination • Weakness • Increased vomiting • Irritable • Gradual loss of consciousness • Disorientation 	<ul style="list-style-type: none"> • Immediately descend to lower altitude • Immediately seek medical attention

Golden Rules of Altitude Sickness (5)

Rule #1

If you feel ill at altitude, it is altitude sickness until proven otherwise.

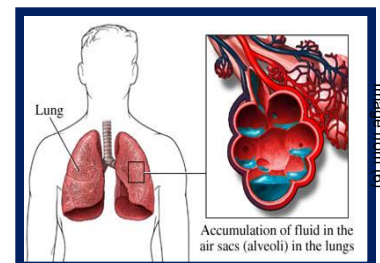
Rule #2

Never ascend to a higher altitude with symptoms of altitude sickness.

Rule #3

If you are getting worse (or have symptoms of HACE or HAPE), immediately return to a lower altitude.

Pulmonary Edema



Cerebral Edema



Comparison of brain with Cerebral Edema (left) and normal brain.

What Causes Altitude Sickness?

Lack of oxygen causes altitude sickness. The air we breathe is composed of nitrogen (78%), oxygen (21%) and other gases (1%) (3). The percentage of these gases in the air, including oxygen, is the same at sea level as it is at high altitudes. However, the number of oxygen molecules per breath is reduced due to the decreasing atmospheric pressure. Atmospheric pressure is a measurement of air's force against a surface. At low elevations, the pressure is greater since the molecules of air are compressed from the weight of the air above them. However, at higher elevations there is less pressure which causes the air molecules to spread out. The barometric pressure at sea level averages 760 mmHg (1013.3 mb), but at 12,000 feet (3,658 meters) the barometric pressure is only 483 mmHg (643.9 mb) causing there to be roughly 40% fewer oxygen molecules per breath (1,3). This, in turn, causes your breathing rate (even while at rest) to increase and deepen in order to properly oxygenate the body. This extra ventilation increases the oxygen content in the blood, but normal blood levels of oxygen are not possible at high altitude. Since the amount of oxygen required for activity is the same whether you are at sea level or high altitude, the body must adjust to having less oxygen. The body adjusts to decreased oxygen levels by (1,3,5):

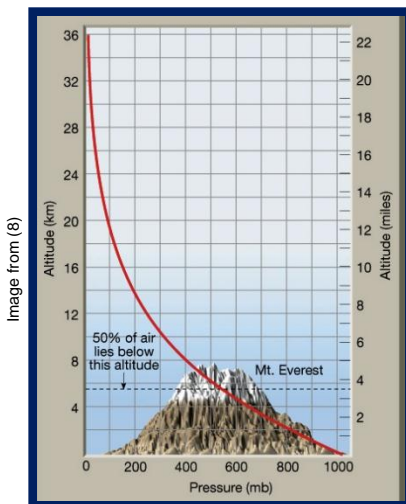
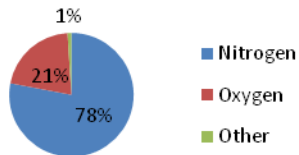
- Hyperventilation (breathing faster, deeper, or both)
- Pressure in pulmonary arteries is increased, "forcing" blood into portions of the lung which are normally not used during sea level breathing
- The body produces more red blood cells to carry oxygen
- The body produces more of a particular enzyme that facilitates the release of oxygen from hemoglobin to the body tissues
- Increased heart rate
- Frequent urination

In addition, for reasons not entirely understood, high altitude and lower air pressure cause fluid to leak from the capillaries which can cause fluid build-up in both the lungs and brain (1). Continuing to higher altitudes without proper acclimatization can lead to potentially serious, even life-threatening illnesses.

Preventing Altitude Sickness

Altitude sickness can usually be prevented by proper acclimatization and/or preventive medications. Always keep in mind that it is easier to prevent many altitude related symptoms than to treat them once they develop.

Composition of Air



Normal blood levels of oxygen are not possible at high altitude.

The body must adjust to having less oxygen.

Preventing Altitude Sickness Cont.

Guidelines for Acclimatization

The major cause of altitude sickness is going too high too fast. Given time, your body can adapt to the decrease in oxygen molecules at a specific altitude. This process is known as acclimatization and generally takes 1-3 days at that altitude. For example, if you work at 10,000 feet (3,048 meters), and spend several days at that altitude, your body acclimatizes to 10,000 feet (3,048 meters). If your work location changes and requires you to work at 12,000 feet (3,658 meters), your body has to acclimatize again. Keep in mind that different people will acclimatize at different rates which requires a lot of patience. If possible, don't fly or drive to high altitude. Start below 10,000 feet (3,048 meters) and walk up. If you do fly or drive, do not over-exert yourself or move higher for the first 24 hours (1). If you go above 10,000 feet (3,048 meters), only increase your altitude by 1,000 feet (305 meters) per day and for every 3,000 feet (915 meters) of elevation gained, take a rest day (1). If at any time you begin to show symptoms of altitude sickness, don't go higher until symptoms decrease. If symptoms increase, go all the way down to starting altitude.

In addition, what you put into your body is important. Remember to stay hydrated as acclimatization is often accompanied by fluid loss. It is also important to eat a high carbohydrate diet (more than 70% of your calories from carbohydrates (1)). Avoid over-exertion, alcohol and other depressant drugs as they can inhibit the acclimatization process (1,3).

Acclimatization does not last forever! Once you descend to lower altitude for longer than a few days (3), you need to take precautions when you ascend again. You will need to reacclimatize to high altitude.

Preventive Medication

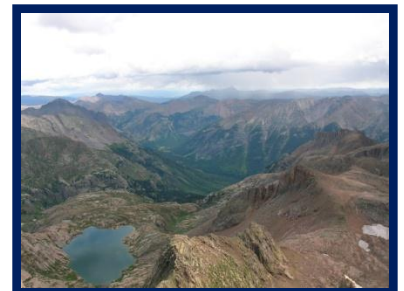
There are two medications that can help speed up your body's natural rate of acclimatization: Acetazolamide (Diamox) and Dexamethasone (1,3). Acetazolamide enables you to breathe more often and deeper so that you can metabolize more oxygen, minimizing the effects of decreased oxygen (1,3). However, this medication has been known to cause severe allergic reactions, which may make this option unavailable to many. Dexamethasone is a steroid that decreases swelling in the brain and may help prevent acute altitude sickness and HACE (3). However, the side effects of steroids and the availability of other prevention strategies make this a poor choice for preventing altitude sickness for most people (3). These medications are not for everyone and should not take the place of proper natural acclimatization where feasible. However, if you are short on time or think they will help you, talk to your doctor.

Ascending Too
High
+
Ascending Too
Fast
=
Altitude Sickness



**Acclimatization
does not last
forever!**

**Reacclimatize to
high altitude if
you have
descended for
more than 3
days!**



Working at Altitude

The ability to work (and work effectively) at altitude is determined by three factors: altitude (high, very high or extreme), duration of exposure (short, long, generations), and individual susceptibility (9). Individual susceptibility plays the biggest role in working capacity at altitude and the ability to adapt based on the duration of exposure.

Altitude - The higher you go, the longer it takes for your body to acclimatize to the new altitude. The time it takes to acclimatize must be taken into consideration when talking about work productivity. You cannot expect to work at full capacity from the beginning. In fact, because the body will be continuously working under conditions with decreased oxygen, 100% work efficiency can not be reached (9).

Duration of exposure - Short term exposures to altitude reduces working capacity in proportion to how high you go. Even after a few weeks of acclimatization, the environmental conditions can still reduce working capacity, especially physical endurance (9). Descendants of natives living at high-altitude have shown to have maximum adaptation. These persons are able to perform very heavy work at high altitudes with the same ease that other people perform similar tasks at sea level (9).

Individual susceptibility - Some people may never be able to acclimatize to certain altitudes based on individual susceptibility. Those who have anemia, respiratory disease and heart disease should not perform heavy work at moderate altitude or any work at high altitude (9). In addition, the combination of decreased oxygen and exercise increases blood pressure making work at altitude dangerous for those with high blood pressure (9).

In addition to work capacity being impaired at altitude, the decreased level of oxygen may result in changes in senses, mood and personality increasing the probability for accidents and injuries. Some effects occur early and are temporary, while others may persist after acclimatization or even for a period of time after descent.

- Vision is generally the sense most affected by altitude exposure, especially the ability to adapt to the dark.
- Mental effects are most noticeable at very high and extreme altitudes and include decreased perception, memory, judgment, and attention.
- Alterations in mood and personality traits are also common at altitude.

Therefore, it is important to be aware of any signs and symptoms of altitude sickness and seek appropriate treatment.



Climax Molybdenum Mine
Colorado, USA
11,360 feet (3,465 meters)



Image from (10)

Pallca Zinc Mine
Peru
16,404 feet (5,000 meters)



Image from (11)

Pascua-Lama Gold Mine
Chile/Argentina
14,763 feet (4,500 meters)

**Working at
Altitude can be
dangerous.**

**Watch for signs and
symptoms and get
treatment if necessary.**

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