Altitude Illness

Traveler Summary

Key Points

- Altitude illness occurs after rapid ascent to altitudes above 3000 m (9,800 ft; due to decreased oxygen), such as flying from sea level to a high-altitude destination. Acclimatization generally occurs by itself, but the time required can be affected by speed of ascent, level of exertion, genetic predisposition, and underlying lung and heart function. Acclimatization rates in first-timers is unpredictable but previous altitude sickness is predictive of repeat problems.
- Altitude sickness comprises 3 syndromes:
  - Acute mountain sickness (AMS; headache, loss of appetite/nausea/vomiting, fatigue) is most common.
  - High-altitude cerebral edema (HACE; AMS symptoms plus more severe headache and changes in coordination and consciousness)
  - High-altitude pulmonary edema (HAPE; AMS symptoms plus progressively worsening breathlessness on exertion and cough)
- Any suspected symptoms of HACE or HAPE *require* immediate descent until symptoms resolve because progression to death within hours is possible.
- *Climb high, sleep low*. No person exhibiting any symptoms should ascend to sleep at a higher altitude; aim instead to sleep at least 300 m (1,000 ft) below highest altitude achieved during the day.
- Persons who may benefit from acetazolamide include those who will ascend to over 2,800 m (9,200 ft) rapidly, those who will ascend to over 500 m (1,600 ft) per day when above 3,000 m, and those with altitude illness.

Introduction

The most serious disorder resulting from travel to high elevations is altitude illness. Minor disorders include periodic breathing, limb swelling, or high-altitude retina damage. Additionally, high altitude/elevation may have adverse effects on travelers with certain preexisting medical conditions, notably, heart, lung, nerve, blood, or hormone conditions. Pregnant women, infants, and young children may require special consideration.

Altitude illness occurs when a traveler ascends to a higher elevation at a rate that precludes the body's ability to adjust. Adjustment to the reduced atmospheric pressure and decreased oxygen delivery to the body's cells at the higher elevation is known as acclimatization, and factors affecting acclimatization include the elevation attained, the rate of ascent, the duration of exposure, genetic predisposition, and certain preexisting conditions. Some people adjust very easily, whereas others cannot go above even moderate elevations without experiencing symptoms. Only past experience can predict whether one will be a good acclimatizer; if symptoms occurred before, they are likely to occur again at the same elevation.

Altitude illness is generally divided into 3 syndromes: acute mountain sickness (AMS), high-altitude cerebral edema (HACE), and high-altitude pulmonary edema (HAPE). Symptoms can range from mild to life-threatening and most can be prevented or minimized by proper acclimatization and/or preventive medications. Risk and prevention strategies vary depending on the type of travel planned, for example, travel to typical tourist destinations at relatively moderate elevations versus trekking in extremely high elevation situations.

Risk of Altitude Illness

Personal Risk Factors

Persons are at low risk if they:

- Have no prior history of altitude illness and are ascending to less than 2,800 m (9,200 ft)
- Allow 2 or more days to arrive at 2,500 to 3,000 m (8,000-9,800 ft) and keep subsequent increases in sleeping elevation to less than 500 m (1,600 ft) per day

Persons are at moderate risk if they:

- Have a prior history of AMS and are ascending to 2,500 to 3,000 m in 1 day

- Have no prior history of AMS and are ascending to more than 2,800 m in 1 day
- Are ascending more than 500 m per day (increase in sleeping elevation) at elevations more than 3,000 m

Persons are at high risk if they:

- Have a history of AMS and are ascending to 2,800 m or higher in 1 day
- Have a prior history of HAPE or HACE
- Are ascending to more than 3,500 m (11,500 ft) in 1 day
- Are ascending more than 500 m per day (increase in sleeping elevation) above 3,500 m
- Make rapid ascents (e.g., < 7-day ascent of Mount Kilimanjaro)

Risk by Type of Travel

Typical Tourist Destinations

Travelers going to typical tourist destinations at elevations of 3,000 m or less rarely experience the more severe forms of altitude illness, such as HACE or HAPE, unless they are genetically predisposed. Mountain resorts are usually located, by design, at elevations ranging from 1,200 to 3,000 m (3,900-9,800 ft). Mild symptoms of altitude illness have been documented at these elevations, and HAPE occurs infrequently at 2,500 to 3,000 m. Daytime activities (e.g., skiing, hiking, sightseeing) may take travelers to higher elevations, but risk is reduced by descending to the lower resort elevation overnight.

Risk increases for those who rapidly ascend (hike vigorously) to destinations higher than 3,000 m and for those who fly (or who are otherwise transported) directly to these relatively higher destinations because these modes preclude gradual acclimatization. Examples of destinations that allow access, without hiking, to relatively high elevations include: La Paz, Bolivia; Lhasa, Tibet; and Cuzco, Peru.

High-Elevation Trekking

Trekkers are at higher risk of HAPE and HACE at high elevations, although the risk is lower compared to that of AMS. Most trekking itineraries take a "one-size fits all" approach toward the pace of the trek and thus cannot guarantee that altitude illness will not occur. Altitude illness affects 50% or more trekkers on popular high-elevation routes. Complications of altitude sickness result in 2 to 3 deaths per year in Nepal. Trekking agencies also feel pressure to offer *shorter* expeditions for busy people who cannot take long holidays. For example, Mount Kilimanjaro treks that summit in 5 days are offered, even when a 7-day ascent already yields elevation gains more rapid than typical Himalaya treks.

Table: Preventive Strategies for Popular Trekking and Tourist Destinations

Destination	Approximate Peak Elevation Attained	Mode of Arrival to Peak Elevation	Comments
Mount Aconcagua, Argentina	6,960 m (22,800 ft)	Trek	Routes to the peak vary in rate of ascent (14-20 days). Descent typically takes 1-2 days. Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the final camp is initiated.
Ojos del Salado, Chile	6,890 m (22,600 ft)	Trek	Routes to the peak vary in rate of ascent (9-15 days). Descent typically takes 1-2 days. Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the final camp is initiated.
Mount Denali, United States	6,190 m (20,300 ft)	Trek	Routes to the peak vary in rate of ascent (12-15 days). Descent typically takes 2-3 days. Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the final camp is initiated.
Kilimanjaro, Tanzania	5,900 m (19,300 ft)	Trek	Routes to the peak vary in rate of ascent (5-9 days). Descent typically takes 1-2 days. Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the final camp is initiated.
Mount Elbrus, Russia	5,640 m (18,500 ft)	Trek	Routes to the peak vary in rate of ascent (4-5 days). Descent typically takes 1-2 days. Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the final camp is initiated.

Annapurna Circuit, Nepal	5,420 m (17,800 ft)	Trek	Most trekkers arrive at Pokhara (up to 1,740 m [5,700 ft]) and can acclimatize gradually during the trek (16-20 days). Because some routes reach significantly higher elevations, acetazolamide chemoprophylaxis is beneficial.
Everest Base Camp, Nepal	5,380 m (17,700 ft)	Trek	Routes to the peak vary in their rates of ascent (10-12 days). Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the starting point is initiated.
Mount Kenya, Kenya	5,200 m (17,100 ft)	Trek	Routes to the peak vary in rate of ascent (4-7 days). Descent typically takes only 1-2 days. Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the final camp is initiated.
Mont Blanc, France and Italy	4,810 m (15,800 ft)	Trek	Travelers typically stay in Chamonix (1,035 m [3,400 ft]) or other villages in the valley (up to 1,462 m [4,800 ft]) and ascend to higher elevations during the day.
Mount Matterhorn, Switzerland	4,480 m (14,700 ft)	Trek	Routes to the peak vary in rate of ascent (2-3 days). Descent typically takes only 1-2 days. Generally, climbers should start acetazolamide chemoprophylaxis 1 day before they ascend and continue until descent to the final camp is initiated.
Inca Trail, Peru	4,220 m (13,800 ft)	Trek	Most trekkers fly from Lima to Cuzco, a rapid ascent. An alternative is to travel via Arequipa (see below for description for Cusco) or descend from Cusco to the Sacred Valley for acclimatization before beginning the trek.
Mount Kinabalu, Malaysia	4,100 m (13,400 ft)	Trek	Travelers typically stay in the coastal town of Kota Kinabalu and travel by bus to the park entrance to begin the climb to an overnight stop at 3,300 m (10,827 ft) before summiting and then descending the next day. Acetazolamide chemoprophylaxis is recommended.
Mount Fuji, Japan	3,780 m (12,400 ft)	Trek	Many mountain lodges at 2,300 to 3,700 m (7,500-12,400 ft) are available for overnight stays for climbers during their ascent.
Lhasa, Tibet	3,650 m (12,000 ft)	Trek	For travelers flying into Lhasa, acetazolamide chemoprophylaxis is recommended.
La Paz, Bolivia	3,640 m (11,900 ft)	Flight	For travelers flying into La Paz, acetazolamide chemoprophylaxis is recommended.
Cusco, Peru	3,400 m (11,200 ft)	Flight	For travelers flying from Lima to Cusco, acetazolamide chemoprophylaxis is recommended. Alternatives to sleeping in Cusco after arriving on a flight are 1) descend to Ollantaytambo (2,800 m [9,200 ft]) for the first 2 nights or 2) go to Arequipa (2,300 m [7,500 ft]) for a few days before using land transportation to Cusco.
Mammoth Mountain, California	3,370 m (11,100 ft)	Trek	Travelers typically stay in Mammoth Lakes (2,400 m [7,900 ft]) or nearby areas and ski at the higher elevations of the mountain.
Quito, Ecuador	2,850 m (9,400 ft)	Flight	Some travelers fly into Quito and may benefit from acetazolamide chemoprophylaxis, whereas others may carry the medication to be used in response to altitude-related symptoms.
Bogota, Colombia	2,640 m (8,700 ft)	Flight	Travelers typically manage the elevation with hydration and rest.
Machu Picchu, Peru	2,430 m (8,000 ft)	Flight	Travelers typically manage the elevation with hydration and rest.
Addis Ababa, Ethiopia	2,360 m (7,700 ft)	Flight	Travelers typically manage the elevation with hydration and rest.
Kathmandu, Nepal	1,400 m (4,600 ft)	Flight	Travelers typically manage the elevation with hydration and rest.

Trek: Denoted elevation reached gradually or in stages by foot or motor vehicle

Flight: Denoted elevation reached immediately upon disembarkation from an aircraft usually originating from a much lower elevation.

Symptoms

AMS symptoms include headache (which can be mild to extremely painful), loss of appetite (which can progress to nausea and vomiting), and extreme fatigue. All headaches at elevations greater than 2,500 m (6,600 ft) should be considered altitude headaches and no further ascent should be attempted until resolution.

HACE begins like AMS but the symptoms become more severe, including changes in consciousness and loss of coordination; HACE can progress rapidly to coma and death and can occur alone or in combination with HAPE.

HAPE symptoms begin as decreased exercise tolerance progressing to severe breathlessness upon exertion and, eventually, even while at rest; substantial chest fullness; and cough (although cough at high elevations is common from other causes). Descent is mandatory as soon as HAPE is suspected because the symptoms can progress rapidly, and death can occur within hours. Unfortunately, exertion considerably worsens HAPE, so exertion by the sick person should be minimized during descent, if at all possible.

Other Conditions

Commonly, individuals who sleep above 3,000 m will have an alteration of their breathing pattern during sleep. The result is a form of periodic breathing in which increasingly deeper then shallower breaths are followed by a brief (5-30 seconds) period of not breathing. If periodic breathing at a high elevation is disturbing to the trekker, acetazolamide (125 mg) taken before bed can relieve the problem.

High-altitude retinopathy (retinal bleeding) is a rare development at high elevations.

Prevention

Nondrug Prevention

Physical fitness at sea level does not influence the risk of altitude illness. Travelers should know the early symptoms of altitude illness and be willing to acknowledge them if they occur. Deaths from altitude illness almost invariably result because symptoms were ignored or not recognized. General acclimatization recommendations:

- Ascend gradually to allow time to acclimatize.
  - Do not ascend directly to elevations higher than 3,000 m, if possible.
  - If an abrupt ascent is unavoidable (e.g., flying directly to the destination), acetazolamide might be needed.
- Avoid alcohol and only participate in mild exercise for the first 48 hours.
- "Climb high, sleep low." If participating in activities at elevations higher than 3,000 m during the day, return to a lower elevation to sleep. Once at 3,000 m, increase the sleeping elevation by no more than 300 to 500 m (1000-1,600 ft) per day.
- Never ascend to sleep at a higher elevation with any symptoms of altitude illness.
- In organized trekking groups, a great deal of pressure exists to keep up with the group schedule so as not to be left behind. If symptoms occur, do not allow group pressure to decide what actions to take.

Drug Prevention

Acetazolamide (Diamox) is most commonly prescribed to prevent altitude illness, but several different medications may be prescribed in certain circumstances.

Acetazolamide (Diamox)

For prevention of AMS: Start taking the drug the day before ascending, take each day during ascent, and continue to take for 24 to 48 hours after arrival at highest elevation.

- Adult dose: 125 mg every 12 hours; 250 mg every 12 hrs if weight is more than 100 kg (220 lb)
- Pediatric dose: 2.5 mg/kg/dose every 12 hours

Precautions:

- Persons with multiple drug allergies or a history of a life-threatening reaction to sulfa drugs should have a test dose of acetazolamide administered in a controlled environment before the trip.
- Persons with an isolated allergy to sulfa antibiotics can take acetazolamide safely.

Side effects:

- Almost always causes numbness of fingers and toes (and occasionally around the mouth)

- Gives carbonated beverages a metallic taste
- Occasionally causes nausea and sensitivity to sunlight

Dexamethasone (Decadron)

For prevention of AMS (in rare situations): 2 to 4 mg every 6 to 12 hours

Precautions: does not prevent HAPE

Side effects: euphoria; can increase the need for insulin or oral agents in diabetics

Ibuprofen (Advil, Motrin)

For prevention of headache: 600 mg every 8 hours, starting a few hours before ascent

Precautions: Risk of gastrointestinal bleeding may be increased at high elevations. Do not use for more than 1 to 2 days.

Side effects: gastrointestinal irritation and bleeding

Nifedipine, sildenafil, or tadalafil may be used for prevention of HAPE in known susceptible individuals but should be prescribed by a clinician well versed in high-altitude medicine.

Other Prevention

Gingko biloba is not recommended for prevention or treatment of altitude illness.

Treatment and Self-Treatment

Nondrug Treatment

Three options are available for treatment. Descent, oxygen, and pressurization bags (portable hyperbaric chambers).

Descent is the treatment of choice for both tourists and trekkers.

- Descent invariably improves altitude illness.
- Descend if symptoms are getting worse while resting at the same elevation.
- Descent until all symptoms are gone is unnecessary because symptoms can take 48 to 72 hours to clear.
- In severe cases, however, descent must continue until clear signs of improvement are recognized or until the person is below the elevation at which symptoms started.

Oxygen is the second treatment choice for both tourists and trekkers.

- Oxygen is available at many tourist locations, often from the front desk of the hotel, and is helpful in treating mild altitude illness.
- Bottled oxygen is carried by many trekking expeditions but is expensive and heavy to carry; therefore, sufficient oxygen is usually not available.

Pressurization bags are another option for trekkers.

- Groups on long treks or climbs to very high elevations (where rapid descent might not be possible) should consider carrying a pressurization bag (e.g., Gamow Bag, Hyperlite, etc.), which can effectively mimic descent.
- A 1-hour treatment in a portable pressurization bag is usually enough to dramatically improve mild to moderate AMS. In more severe cases, several hours in the bag may be necessary.

Drug Treatment

Discuss with the health care provider what drugs might be used for treatment and when to use them. For side effects and precautions, see drugs listed under Prevention.

Acetazolamide (Diamox)

Diamox is used for treatment of AMS or periodic breathing and sleep apnea at higher elevations.

Dexamethasone (Decadron)

Dexamethasone is effective in treating mild to moderate AMS and in improving HACE.

Ibuprofen and aspirin are effective in treating headache associated with high elevation.

Effect of High Elevations (> 2,500 to 3,000 m) on Preexisting Medical Conditions

Breathing air and oxygen pressures decrease with an increase in altitude/elevation. Acclimatization compensates for this difference over a few days. Most mountain resorts are situated at elevations below 2,500 to 3,000 m above sea level, the elevation at which the acclimatization mechanisms take effect. These mechanisms increase demand on a person's heart, lungs, red blood cell production, and the blood's oxygen-carrying capacity, which can affect persons with underlying medical conditions.

In general, the more severely limited one's exercise tolerance is at sea level, the worse it will be at higher elevations. Some high-elevation destinations are far from the nearest medical help. Some travelers with preexisting conditions should avoid trekking if medical care is not readily available.

Cardiovascular System

Travelers with Chronic, Stable Cardiac Conditions

The risk of new ischemic (restricted blood flow) cardiac events at high elevations appears to be extremely low, no higher than at low elevations. However, sudden cardiac death (SCD) is the most frequent cause of nontraumatic death in males older than 34 years during leisure time activities (e.g., downhill skiing and hiking) at elevations of 3,000 m. Although a prior heart attack is the most important risk factor for SCD, other triggers that may unmask unknown ischemic heart disease at higher elevations include unusual physical activity during the first days upon arrival and prolonged abstinence from food and fluid intake during exercise.

Individuals who do not engage in physical activity at low elevations should not do so at high elevations. The ability to hike steadily for at least 4 hours over steep terrain should be a minimum requirement for trekking in high mountains.

Certain drugs used to treat heart failure (beta blockers and angiotensin-converting enzyme [ACE] inhibitors) and the diuretic acetazolamide may interfere with acclimatization, but no evidence of harm exists.

Blood pressure increases modestly and steadily during ascent to high elevations, although the response varies between individuals and by method of measurement. Travelers with high blood pressure who are well controlled on medications and who are going for a short tourist trip to moderate elevations do not need to adjust dosage. However, trekkers going to elevations higher than 4,000 m should monitor their blood pressure; treatment may need to be adjusted.

Travelers with Unstable Cardiac Conditions

In general, persons with unstable heart conditions should not fly without special precautions and are therefore unfit for travel to high elevations.

Differentiating between angina, breathlessness at high elevation, and HAPE can be extremely difficult, which could result in delayed recognition and treatment of the condition. Thus, persons with angina, even if controlled at sea level, should be discouraged from high-elevation trekking.

Persons with congestive heart failure can experience difficulties at high elevations because even a little stress on the heart can induce failure. Travelers should limit themselves to moderate activity and stay in an area where medical care is readily available. Travelers with uncompensated congestive heart failure should avoid going to high elevations.

Persons with uncontrolled ventricular arrhythmia should neither fly nor travel to high elevations.

Pulmonary System

Persons with chronic obstructive pulmonary disease or primary pulmonary arterial hypertension should avoid trekking. Persons with mild, well-controlled asthma have generally done well at higher elevations, possibly due to the greatly decreased presence of allergens at high elevations. However, persons with asthma should carry their medications with them at all times; travel should be avoided in the setting of worsening control or a recent exacerbation. Persons with moderate to severe persistent asthma should exercise extreme caution if going to high elevations.

Neurological System

Persons with uncontrolled or poorly controlled seizures should avoid high elevations. A history of migraines increases risk of headaches at higher elevations.

Hematological System

Even moderate altitudes, such as those encountered in airplane travel, can trigger a sickle cell crisis in a person with sickle

cell trait (SCT) or disease. Typical tourist elevations will often cause a crisis, even without physical exertion. In both SCT and disease, significant physical exertion increases risk of sickle cell crisis at low elevations, and less exertion is required to precipitate a crisis at higher elevations, even at elevations tolerated at rest. Dark-skinned persons born outside the U.S., especially in developing countries, may never have been tested for SCT as children and may be at risk of a sickle cell crisis and should be tested prior to any high-elevation travel.

Persons with low red cell counts from other causes could experience difficulty adjusting to high elevations because their oxygen-carrying capacity may already be low; they should proceed with caution. Persons with polycythemia could have a risk of blood clots.

Endocrine System

Persons with stable diabetes can travel safely to high elevations if they are comfortable with self-monitoring and pay very close attention to their glucose balance. Glucose meters may provide inaccurate glucose readings and insulin pumps may administer incorrect doses at high elevations. Additionally, it may be difficult to keep insulin supplies at close hand and unfrozen during a long, cold, backcountry journey.

Other Considerations

Pregnancy

Pregnant women should avoid high-elevation trekking because medical care (in the event of early labor or other complications) may not be readily available. Short stays at intermediate elevations up to 2,500 m appear to be low risk for women after 20 weeks gestation with uncomplicated pregnancies. Pregnant women should avoid sleeping at elevations above 3,000 m because blood oxygen saturation may not be well maintained. The main drugs used for altitude-illness prevention or treatment (acetazolamide, dexamethasone, and nifedipine) have been shown to cause birth defects in animals but have not been well studied in humans; however, they may be recommended if the benefits outweigh the potential risk.

Infants and Children

Travel to elevations up to 2,500 m is low risk for healthy children. Children are at risk for AMS just as adults are, but symptoms may be more difficult to assess in young children, especially those who are not yet talking. For prevention, acetazolamide may be advised.

HAPE and HACE are not well reported in traveling children due to the infrequency of children traveling to high elevations, but HAPE may be more likely to occur when the child also has a viral illness. For treatment of AMS and HACE in children, dexamethasone might be advised.

Oral Contraceptives

Concerns exists that the increased risk of blood clots in women taking oral contraceptives at sea level might be compounded by high elevations. Women taking oral contraceptives who will not spend much time at elevations above 4,200 m (13,800 ft) can continue to take oral contraceptives. Women climbing at extremely high elevations on expeditions (above 6,000 m; 19,700 ft) should consider discontinuing oral contraceptives to avoid the potential increased risk of blood clots.