Low- Altitude Hypoxia

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Abstract: Using oxygen at altitudes below that required by regulations can improve performance and mitigate the likelihood of cognitive pilot error. Portable oximetry is useful in estimating individual need and benefit, if used with understanding.

Introduction:

"Lack of oxygen dulls the mind and judgment, slows the reflexes, weakens the muscles, and takes away our higher faculties. The higher one goes, the more serious are these effects. Too many people forget this exactly at a time when they should be most responsive to the danger." (Houston)

There is little data (that I can find) on cognitive impairment from mild hypoxemia – but plenty of anecdotes, and each person has unique experiences. See **Table 1** for a summary of saturation, altitude, and cognitive change.

We are far more sensitive to hypoxia than the regulations recognize. They are concerned with incapacitation, and flying is usually such a simple, straightforward task that pilots have often returned to brag from flights without oxygen above 6 km (20,000 ft) MSL. However, none of them could have worked a calculus problem up there, or subtracted a compass heading (it wouldn't have seemed important, anyway; lethargy being a symptom of hypoxia).

Anyone who's donned oxygen while flying at night at 1.5 – 2 km (5-7k ft) MSL can tell you how quickly the lights on the ground went to 'bright.' (They don't mention that the brain also went to 'bright.')

It's known that smokers function as if they are 1-1.5 km (3-5k ft) higher than the altitude on the altimeter. In this regard, it's important that carbon monoxide is a problem is several ways.
- It ties up, generally, 3-10% of hemoglobin and permanently prevents it from transporting oxygen to the brain.
- It decreases the ability of hemoglobin to release oxygen into the tissues where it's needed.
- It interferes in all tissues with metabolism even at low concentrations (5-9%) by interfering with the heme-containing proteins that are centrally important in energy transport.
- It makes the oximeter read falsely high. Carboxyhemoglobin levels in nonsmokers are less than 2%, while they may be as high as 10-20% in heavy smokers. COHb resemble[s] oxyhemoglobin in the red range, and thus looks like oxyhemoglobin, causing the pulse oximeter to over-read. For every 1% of circulating carboxyhemoglobin, the pulse oximeter over-reads by 1%. Fifty percent of cigarette smokers have a Carboxyhemoglobin concentration of 6%. Thus, the most important limitation of pulse oximeters is that they are inaccurate when pilots need them the most.

The net of this is that smokers should always carry oxygen, and should always use it beginning at about 1.5 – 2 km (5-7k ft) above their home airport elevation, and the regulatory limits should be decreased by 1-1.5 km (3-5k ft). Pilots who've smoked for more than about 20 years, do have impaired lung function, and should plan on using oxygen at lower altitudes – a finger oximeter is the best guide to just when to use it, keeping saturation in the mid nineties or above for peak performance.

It's important to realize that respiratory physiology is that of a young, healthy body. In my clinical experience, mild (often undiagnosed) asthma is common. Any lung disease will likely cause some deficiency of oxygen absorption, Anemia is common in older people and results in impaired oxygen transport to tissues.

A challenge for understanding oxygen need and effect is that our bodies have no oxygen detector. Breathing is driven by carbon dioxide level and by acid-base balance.

Shortness of breath is not caused by low oxygen – but by whatever increases the work of breathing (resistance to airflow, lung stiffness from asthma, fibrotic tissue, infection, or venous congestion), alters the blood acid-base balance, or alters the carbon dioxide content.

Pulse oximetry:

Finger pulse oximeter readings are often inaccurate and misleading – but they are useful! One must understand the conditions in which they are prone to error, and make allowance.

Every electronic measuring device will display numbers if powered up. The question is, What is the relationship between reality and the displayed number? This is the main question of metrology, the science of measurement, which really is the science of measurement error.

In looking at measurements, we need to keep in mind that precision (the number of digits after the decimal)does not indicate accuracy (the connection of the number to reality). Oximeters get less accurate when the readings are more important - lower than normal because signal may be eclipsed by noise.

Manufacturers claim their readings are +/- 2% or +/- 3% in the range of 70-100% saturation. This means that when the oximeter reads precisely 87%, your actual blood oxygen saturation is probably in the range of 84- 90% for the less accurate, 85-89% for the more accurate – in the best laboratory conditions, which your cockpit is not! What can delude this instrument?
- Sunlight can "overpower" the unit's own spectrophotometric light source. Some models have better shielding than others.
- Pigmented skin yields lower saturation readings when actual values are in the 80% range.
- Fidgeting degrades their accuracy by 5-20% (that is, with a true O2 saturation of 95%, the meter may read 75-90%)
- The oximeter is measuring the oxygenation of the blood in the fingertip. What really matters is the oxygenation of the blood flowing through the brain.
- Cold fingers have low blood flow, so readings will be low. Only measure warm fingers. Yes, this is a problem for wave flights.
- Carbon monoxide falsely elevates saturation readings due the color of carboxyhemoglobin.
- Hyperventilation which typically happens with altitude, increases peripheral oxygenation while decreasing brain oxygenation, so readings are spuriously high.

With these limitations, oximeters are most useful to reassure you that your oxygenation is OK (90+%), or that you should don oxygen or troubleshoot the situation (85% or below).

They are also useful for self-assessment – for any give reading below about 95% saturation, how do you feel? How well is your brain working? Can you subtract compass headings? Re-program your flight computer adroitly? Do you feel enthusiasm and energy for the task at hand?

If you sense any cognitive clouding for complex mental tasks, turn on the oxygen, and correlate you brain's function with oximeter readings.

The most important reason to evaluate your personal oxygen need is the "I feel fine" problem. Our brilliant minds and superb motor skills depend, for excellence, on our neurochemistry working just right. However, our bodies' impairment-detector is pretty much a near-death detector, and ignores and compensates for mild annoyances (to do otherwise would create continual distractions).

Don't assume that what you need one week will be correct for you the next. The respiratory system normally acclimates and de-acclimates to altitude in just days; respiratory infection, exposure to smoke or fumes, or variable activity of asthma may change your day-to-day oxygen physiology and need.

Pulse oximeters are readily available at prices from $15 to $300. I cannot find comparative performance and reliability data; Nonin was the first to market, if that means anything.

Conclusion:
The rapid ascent of aircraft does not permit any acclimatization to altitude. It is the experience of many pilots that subtle hypoxia causes small but noticeable loss of acuity, motivation, or alertness. The pilot who needs peak performance will benefit from using low-flow supplemental oxygen at altitudes much lower than required by regulation to prevent impairment.

Smokers should always carry oxygen, and should always use it beginning at about 1.5 – 2 km (5-7k ft) above their home airport elevation, and 1-1.5 km (3-5k ft) before reaching the regulatory altitude, due to carbon monoxide impairment of oxygen absorption and transport.

References:

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Figure:

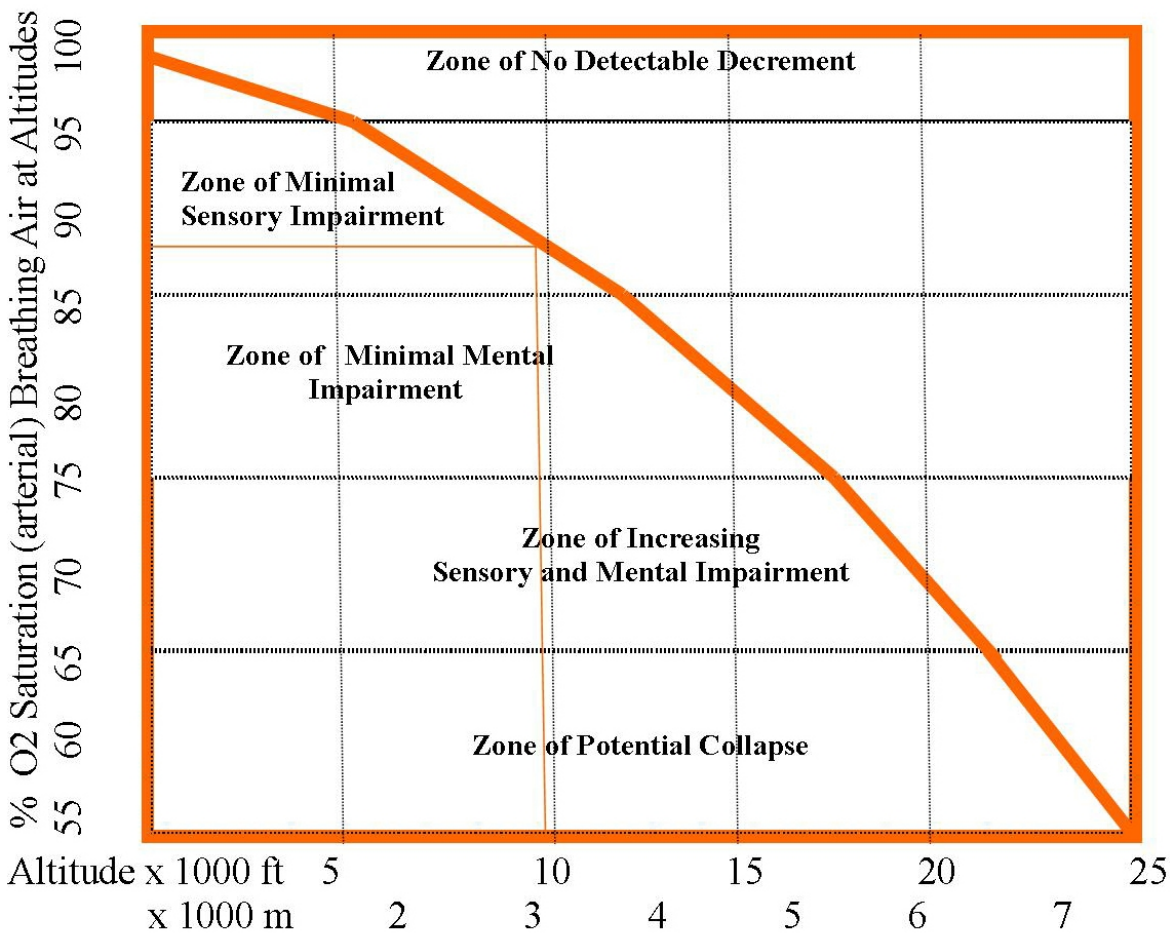

Table 1: Cognitive function v. altitude v. oxygen saturation