

Altitude Tents: How High the Risk?

Altitude tents simulate altitude by reducing the oxygen content of inspired air in a closed environment.

There are theoretical reasons and experimental data to indicate that altitude tents may improve athletic performance. Potential side effects/risks of tent use are discussed.



CYCLE
HANDOUT

Background

Altitude tents are increasingly being used by aerobic-endurance athletes including cyclists, runners, triathletes, and cross-country skiers. Typically, athletes residing near sea level sleep in their altitude tents at night.

The oxygen content of air is often reduced to correspond to an altitude of about 10,000 feet, occasionally higher.

In my experience, users fall into two groups: (1) professional or semi-professional athletes (2) competitive age-group Masters athletes with disposable income.

Relevant Questions

- Do altitude tents improve performance at sea level? (For some, probably yes.)
- Do altitude tents improve performance at altitude? (For some, probably yes.)
- How big an improvement at might be expected? (Perhaps 1% to 2% at sea level; perhaps much more at altitude.)
- Do altitude tents aid acclimation/prevent altitude sickness? (Probably yes.)
- Do altitude tents have risks? (Probably yes.)

Although the risks of altitude tent use are the focus of this article, how these devices work helps understand the reasons for the risks.

Performance

Overall, the general feeling over the last couple of decades is that sleeping in altitude tents improves sea-level and altitude performance. Generally, at least 3 weeks of roughly 8 hours per night are recommended before an event.

I comprehensively reviewed the literature and published an analysis about 10 years ago.¹

¹ http://arniebakercycling.com/handouts/ht_fa_altitude_training_for_sea_level_competition.htm.

Since then, the basic conclusions are the same: Although some scientists have found improvement in performance with the use of altitude tents, not all do.

Note: Not all aspects of performance improve. Studies tend to look at VO₂ max as an endpoint. The studies are most relevant events where VO₂ max is critical, such as 60-minute time trials and hill climbs. In such events, performance improves about 1 minute per hour. When other factors limit performance, improvement is less certain.

Although performance improvement may be statistically significant, and practically important to competitive racers, it is often of small value to recreational riders.

Consider, for example, a 6-hour bicycling event for a strong recreational rider, such as a century. If performance improves 1% to 2%, about 6 minutes, is such an improvement important to the rider?

The way in which altitude tents improve performance, if such an improvement is real, is not settled.

It might be predicted that the lack of oxygen in the tent would stimulate the kidneys to produce erythropoietin (EPO), and that this EPO would cause the bone marrow to increase red blood cell production.²

The increase in red cells, with their increase in oxygen carrying capacity, might thereby improve performance. Some studies indicate this is true.

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² EPO levels often rise within minutes of deprived oxygen exposure in a tent. Of course, such an increase in EPO caused by sleeping in the tent might be temporary. In the morning, at sea-level, when not in the tent, EPO levels would fall and then might be expected to return to normal or below normal until next in the tent. A question would be, overall, are EPO levels higher in a 24-hour period?

Some who improve performance after using an altitude tent do not change the total number of their red blood cells.

Improvement might occur because sleeping in a tent may (1) decrease blood volume. A decrease in blood volume may translate to an increased concentration of red blood cells, but not absolute number. This decrease in fluid volume would result in a lighter rider. A lighter rider might climb better solely because of the weight loss. Alternatively, perhaps a more concentrated blood improves performance.

Improvement might come because sleeping in a tent may (2) increase muscle myoglobin (the muscle equivalent of the blood's hemoglobin, transporting oxygen in the cell), or increase mitochondria, the cell factories.

Normally, the hematocrit, or percentage of the blood that is red cells, is about 40% to 44% in women and 44% to 48% in men. Endurance athletes are often a few points lower. Sport governing bodies sometimes limit the hematocrit of athletes to about 50%.

(Alternatively, the amount of hemoglobin, the oxygen-carrying protein in red blood cells, is measured. Roughly, each gram of hemoglobin corresponds to about 3 percentage points of hematocrit.)

Again, the results of studies examining these issues are mixed.

Altitude Sickness

Altitude sickness (mild, including headache, nausea, fatigue, and decreased aerobic performance; to severe, including lung and brain swelling) does not result from a lack of red blood cells. The mechanism of altitude sickness is not certain. It may be related to acid-base balance.

Altitude tents may reduce the frequency of altitude sickness.

Studies are limited in number and design.³

Side Effects

Altitude tent studies are designed to test the hypothesis that altitude tents improve human performance.

They are generally not designed to look at the short- or long-term consequences of such use—and such problems are rarely noted.

³ For example, Beidleman, BA, et al. *Intermittent altitude exposures improve muscular performance at 4,300 m*. *J Appl Physiol*. 95. 1824-1832. 2003. The study found a roughly 20% improvement in cycling performance at altitude. The study had only six subjects, was uncontrolled, and was not blind.

Although the use of altitude tents may have physiological or medical consequences, altitude tents are not “medical devices,” with oversight or regulation by the World Health Organization or US Food and Drug Administration.⁴

Consider two important health issues of our time: The risks of (1) cigarette smoking and cardiovascular disease, or (2) postmenopausal estrogens and breast cancer.

The dangers of smoking or hormone replacement therapy are important issues in public health. However, perhaps hundreds of millions of users smoked or used postmenopausal estrogens for decades before the risks were understood or accepted.

Now consider the small numbers of tent users, perhaps in the low thousands. There is no registry interested in documenting side effects.

What follows, is of necessity, anecdotal (based on published reports or on personal contacts with roughly 50 athletes who have used tents) or based on general medical principles.

Nuisance Side Effects: Insomnia and Decreased Recovery

The intermittent or continuous background noise (“white noise”) of the device may improve sleep for some.

Others have problems.⁵ Some are restless or find recovery more difficult, especially those who simulate too high an altitude too quickly.

Some tents are designed with temperature control, humidity control, and carbon dioxide scrubbers. Those who sleep in tents without these features may find the air hot, humid, or otherwise uncomfortable.

The reduced oxygen content of air might be expected to make recovery more difficult or have no effect on recovery. It is unlikely to assist recovery.⁶

Many athletes lose a pound or two of water weight the first night or two sleeping in an altitude tent. Increased urine production may mean more interrupted sleep to urinate.

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⁴ For some background discussion about the regulation of medical devices, see http://www.who.int/medical_devices/publications/en/MD_Regulations.pdf or <http://www.sciencedaily.com/releases/2008/01/080110105749.htm>.

⁵ Ljungqvist, A. Testimony before the (British) House of Commons Science and Technology Committee, November 29, 2006. “With regard to hypoxic chambers... More and more athletes experienced negative side effects.”

⁶ Although there have been limited studies showing no decrease in recovery with the use of tents, lack of proof of effect is not the same as proof of lack of effect. Many athletes have reported that they do not use their tents after hard workouts.

Life Threatening Side Effects: Cardiovascular Disease

If altitude tents work by increasing the number of red blood cells or by concentrating blood, they could pose important health risks.

Again, the numbers of athletes who have used these devices is relatively small, and the long-term safety has not been studied/is not established.

HIGH BLOOD PRESSURE

It is medically reasonable to think that if altitude tents increase red blood cells, such an increase might be associated with high blood pressure. High blood pressure is associated with cardiovascular disease—heart disease and stroke—the number one killer.

KNOWN EPO RISK: HEART DISEASE AND STROKE

In the last few years we have learned from those who have anemia and have been given EPO (because of kidney disease or cancer, for example), that even approaching low-normal red blood cell counts increases the risk of cardiovascular events such as heart attack and stroke—perhaps by 50% or so—relative to keeping a modest anemia. Physicians who treat such patients are now advised to keep their patients moderately (not severely) anemic. That is, hemoglobin below 12 or a hematocrit below about 35.⁷

Although a 50% increase in risk may not be of real-world importance to a 30-year old whose absolute risk is relatively low, this relative risk may be prohibitively high for those with preexisting heart disease or those over a certain age—say 50 years.

Increasing hematocrit beyond “normal” levels (40% to 48%) might be presumed to pose even higher risks than increasing levels to 35%.

KNOWN RISK: TOO MANY RED BLOOD CELLS

1. The classic and pivotal Framingham study showed that there is a direct relationship between the risk of stroke and the hemoglobin level, even within the normal range of values.⁸

⁷ *The Medical Letter*. Issue 1260. May 7, 2007.

⁸ Kannel, WB, et al. *Hemoglobin and the Risk of Cerebral Infarction: The Framingham Study*. *Stroke*. 3. 409-420. 1972. “Risk of cerebral infarction over 16 years was ascertained in 5,185 men and women classified according to their hemoglobin, blood pressure and cigarette habit on entry to the Framingham Study. Within the normal range of hemoglobin values, risk was found to be proportional to the blood hemoglobin concentration in both sexes.” Smoking and hypertension were found to be dependant risk factors.

2. In the medical condition polycythemia vera, the body produces too many red blood cells.

One treatment of such patients is phlebotomy—removing blood. The current approach is to remove blood when the hematocrit is above 42% to 45%. The reason for this is simple: higher hematocrits are associated with higher mortality in this population.⁹

RISK OF LIVING AT ALTITUDE

If altitude tents are designed to simulate living at altitude, what information is available about the risks for those who do live at altitude?

Studies are limited in number and design.¹⁰

Jaillard found that the incidence of stroke in Cuzco, Peru (11,090 feet) was increased and associated with an increase in the number of red blood cells.¹¹

Al Tahan compared the incidence of stroke in al Baha (> 6,500 feet) versus Riyadh (2,030 feet) meters.¹² “The study's finding of an increased frequency of thrombotic stroke at high altitude was explained by increased hematocrit.”

Jha found that an increase in hematocrit was an important risk factor in stroke for soldiers in the Indian mountains.¹³

In contrast, Mahajan found that the incidence of stroke in the Pradesh of India was lower at moderate altitude than at sea level.¹⁴

RISK FOR AIRPLANE FLIGHT CREWS

Airplane flight crews are commonly exposed to cabin pressures corresponding to about 8,000 feet.

As with the risk of living at altitude, studies would be expected to be limited by design.

I know of no studies that address the risk to airplane flight crews.

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⁹ Wikipedia. Polycythemia vera. Accessed December 1, 2008. http://en.wikipedia.org/wiki/Polycythemia_vera.

¹⁰ Unlike studies that have examined giving EPO to patients with kidney disease or cancer, or studies phlebotomizing polycythemia vera patients, the design of studies of those living at altitude rarely can fit the gold standard: prospective, controlled, double-blind, and randomized.

¹¹ Jaillard, AS, et al. *Prevalence of Stroke at High Altitude (3380 m) in Cuzco, a Town of Peru*. *Stroke*. 26. 562-568. 1995.

¹² Al Tahan, A, et al. *Risk factors of stroke at high and low altitude areas in Saudi Arabia*. *Arch Med Res*. 29. 173-177. 1998.

¹³ Jha, SK, et al. *High Altitude Medicine & Biology: Stroke at High Altitude: Indian Experience*. 3(1): 21-27. 2002. “All our cases from high altitude area were males (serving soldiers of armed forces). Their mean high altitude stay was 10.2 months, and they were all located at heights greater than 4270 m. Age ranged from 22 to 48 years (mean 33.4 yr).”

¹⁴ Mahajan SK, et al. *Stroke at moderate altitude*. *J Assoc Physicians India*. 52. 699-702. 2004.

THEORETICAL RISK: DEFECTIVE BLOOD VESSELS

One long-term (years) adaptation to reduced oxygen is the formation of new blood vessels (angiogenesis).

Long-term altitude tent exposure might result in new blood vessel formation.

Intermittent altitude exposure while sleeping might result in defective blood vessel architecture.

If these new blood vessels are fragile, they could burst (causing, for example, a stroke).

Again, this is entirely theoretical.

However, this rational argument reminds one that unanticipated side effects are common in medicine and that the long-term safety of tents is unestablished.

Summary. Recommendations

It is uncertain whether altitude tents are a risk factor for cardiovascular or other diseases.

The use of an altitude tent might make sense for 20- to 40-year old professional aerobic athletes, in whom the absolute risk may be expected to be relatively low.

Masters athletes and those with cardiovascular risk factors should balance possible improvements against uncertain risks before using altitude tents.

Call for Feedback

If you know of additional studies that address the issues discussed in this article, please contact me: arnie@arniebakercycling.com.

Thank you.

Disclosure

Dr. Baker has consulted for Colorado Altitude Training, a manufacturer of altitude tents.

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