# Mountain climbing without the headaches caused by altitude

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By monitoring blood flow in the brains of six climbers scaling Mount Kilimanjaro in Tanzania, German medical researchers have identified a possible way to prevent the headaches that are a common feature of altitude sickness. This work appears in the latest issue of *JNIRS—Journal of Near Infrared Spectroscopy*.

Other features of altitude sickness include fatigue, digestive problems, weakness and dizziness. They are all caused by the decrease in the partial pressure of oxygen at altitudes above around 2500 m, as the number of oxygen molecules in a given volume drops. This produces an associated decrease in the concentration of oxygen in the blood and results in less oxygen reaching the brain. After a few days, most people naturally acclimatise and the symptoms of altitude sickness disappear.

Breathing patterns can also be affected by the fall in the partial pressure of oxygen at high altitudes. This doesn't tend to be noticeable when awake, because climbers consciously regulate their breathing. When sleeping at high altitudes, however, climbers tend to alternate between rapid, deep breathing (hyperventilation) and then much slower, shallower breathing (hypoventilation), sometimes briefly stopping breathing altogether (apnoea), with each cycle lasting for around 30 seconds. This is all down to how the body reacts to varying concentrations of oxygen and carbon dioxide ($CO_2$) in the blood.

"The lack of oxygen at high altitude causes the climbers to hyperventilate, which leads to a decline of $CO_2$ in the blood," explains

Peter Stein, who is in the department of anesthesiology, intensive care medicine and pain therapy at University Hospital Frankfurt. "The decline of CO2 leads to episodes of hypoventilation or even apnoea when the conscious breathing control subsides during sleep. As a consequence the oxygen level drops, causing an arousal and subsequent hyperventilation."

Stein and his colleagues wanted to discover whether this abnormal breathing pattern was reducing the supply of oxygen to the brain, potentially worsening the effects of altitude sickness. To find out, they turned to NIR spectroscopy, an analytical technique that detects specific molecules based on their absorption and reflection of light at near infrared wavelengths. Specifically, Stein and his colleagues wanted to use NIR spectroscopy to monitor changes in the concentration of haemoglobin, both oxygenated and deoxygenated, in the blood supply to the brain.

So they accompanied six climbers as they scaled Mount Kilimanjaro, the highest free-standing mountain in the world at 5895 m above sea level, attaching NIR electrodes to the climbers' foreheads while they slept to monitor haemoglobin concentrations. "The most challenging part was to transport not only the NIR spectroscope into basecamp but also all the equipment necessary to provide electricity," says Stein. "Therefore we bought a lightweight generator and enough fuel to provide power throughout all the nights."

What they discovered was that the abnormal breathing pattern caused periodic changes in the concentration of oxygenated haemoglobin and total haemoglobin, but not in the concentration of deoxygenated haemoglobin. This indicates that although the abnormal breathing pattern did alter the flow of blood into the climbers' brains, it didn't reduce the amount of oxygen reaching their brain tissue.

The researchers also discovered, however, that those climbers experiencing the most extreme periodic changes in haemoglobin concentrations in the brain as they slept were also those that suffered most from headaches at high altitudes. This suggests that one simple approach to preventing these headaches is to find ways to stop the abnormal breathing that occurs when sleeping at high altitudes.

"Our experiments reveal a pathomechanism contributing to the aetiology of the most common symptom of altitude sickness: headache," says Stein. "I hope that based on our findings it will be possible to develop new therapeutic approaches that help to increase comfort and safety for climbers in the future."

**More information:** P. Stein, A. Lampe, A. Pape, K. Zacharowski, R. Hudek and C.F. Weber, "Sleeping on Mt Kilimanjaro—The influence of hypobaric hypoxia on brain perfusion and cerebral tissue oxygenation" *J. Near Infrared Spectrosc*. 22, 1 (2014) DOI: 10.1255/jnirs.1088

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