Minor heart feature may mean trouble at high altitude

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Andrew Lovering of the Department of Human Physiology at the University of Oregon has linked a common heart flap that doesn't close normally in infancy to serious health complications in individuals going into high altitudes. Credit: Charlie Litchfield

A common heart feature long thought to have negligible effects on human health and performance may be problematic at high altitude, according to University of Oregon researchers.

That's a key finding from a study that looked at the effects of a condition known as patent foramen ovale in a high-altitude Bolivian setting. The study was published in the *Journal of Applied Physiology*.

The foramen ovale is a small flap-like opening usually present between the right and left upper chambers of the human heart that normally closes during early infancy. A foramen ovale that doesn't close is known as a patent foramen ovale, or PFO. Recent research suggests approximately 40 percent of adult humans have a PFO.

"This seemingly insignificant heart condition had significant impacts on human physiology at high altitude, including reduced breathing response, a reduced ability to oxygenate the blood and increased susceptibility to acute mountain sickness," said the paper's co-principal investigator Andrew Lovering, a professor of human physiology.

The study stems from a six-week-long 2012 research expedition involving 15 scientists and 21 subjects, many of them UO students. It is the first such effort to examine the effects of PFO on acclimatization to high altitude.

For their research, Lovering's nine-member team divided subjects into PFO and non-PFO groups and studied them at rest and during exercise. The tests were performed at sea level, repeated after arriving at a 17,257-foot-high research facility on Bolivia's Mount Chacaltaya and again after 16 days at altitude.

Researchers recorded gas exchange efficiency—a measure of how well the lung oxygenates the blood. They looked at markers of

acclimatization to high altitude such as increased ventilation and reduced incidence of acute mountain sickness.

The team found that PFO subjects did not improve their pulmonary gas exchange efficiency with acclimatization to high altitude—both at rest and while exercising, as non-PFO subjects did—and experienced an increased incidence of acute mountain sickness. Researchers saw little difference between the two groups at sea level and immediately after arriving at altitude.

Researchers believe that, due to a number of factors PFOs may impair performance at, and limit acclimatization to, high altitude. Such factors include PFOs being a potential source of right-to-left intracardiac shunt, a pattern of blood flow that can impair pulmonary gas exchange efficiency. In simple terms, Lovering said, the PFO allows for blood to bypass the lungs so that blood will not pick up oxygen.

Most surprising to researchers was that, even after two weeks of living at 17,000 feet, the PFO subjects didn't increase ventilation to the same extent as the subjects without PFO. Forty percent of the PFO subjects were still suffering from acute mountain sickness after five days at altitude, whereas 10 percent of subjects without PFO still had acute mountain sickness at five days.

Researchers do not know why there were such stark differences in breathing between the two groups. In future work, they will seek to determine whether subjects with PFO simply need more time to acclimatize to high altitude. Researchers also want to perform studies at less-extreme altitudes and examine bigger groups of subjects.

The research is part of a larger research program on AltitudeOmics that includes the paper's co-principal investigator Robert Roach, director of the Altitude Research Center at the University of Colorado Denver

School of Medicine.

By examining how humans respond to low oxygen, the team hopes to gain a better understanding of other disorders. Low oxygen is a threat in many lung and heart diseases, and is a driver for growth of many types of cancer.

In a separate paper, accepted for publication in the *Journal of Physiology*, Lovering's team studied respiratory system cooling in 30 subjects, half with PFO, during sea-level exercises. Subjects with PFO had warmer resting body temperatures and had difficulty cooling down when given cool air to breathe.

"PFO has been known since the times of Claudius Galen," said Lovering, referring to a second-century Greek physician. "It's very surprising that it has taken researchers this long to examine the impact of this very common heart condition on high altitude physiology."

More information: *Journal of Applied Physiology*, jap.physiology.org/content/118/9/1100

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