A gene that controls red blood cell production evolved quickly to enable Tibetans to tolerate high altitudes, a study suggests. The finding could lead researchers to new genes controlling oxygen metabolism in the body.

An international team of researchers compared the DNA of 50 Tibetans with that of 40 Han Chinese and found 34 mutations that have become more common in Tibetans in the 2750 years since the populations split. More than half of these changes are related to oxygen metabolism.

The researchers looked at specific genes responsible for high-altitude adaptation in Tibetans. By identifying genes with mutations that are very common in Tibetans, but very rare in lowland populations we can identify genes that have been under natural selection in the Tibetan population, said Professor Rasmus Nielsen of the University of California Berkeley, who took part in the study. ‘We found a list of 20 genes showing evidence for selection in Tibet – but one stood out: EPAS1.’

The gene, which codes for a protein involved in responding to falling oxygen levels, and is associated with improved athletic performance in endurance athletes, seems to be the key to the Tibetan adaptation to life at high altitude. A mutation in the gene that is thought to affect red blood cell production was present in only 9% of the Han population, but was found in 87% of the Tibetan population.

‘It is the fastest change in the frequency of a mutation described in humans,’ said Professor Nielsen.

There is 40% less oxygen in the air on the 4000 m high Tibetan plateau than at sea level. Under these conditions, people accustomed to living below 2000 m – including most Han Chinese – cannot get enough oxygen to their tissues, and experience altitude sickness. They get headaches, tire easily, and have lower birth rates and higher child mortality than high-altitude populations.

Tibetans have none of these problems, despite having lower oxygen saturation in their tissues and a lower red blood cell count. Tibetans have higher child mortality than high-altitude populations.

‘It just summed Everest a few weeks ago,’ added Dr Wang. He said the Sherpas and Tibetans were much stronger than the Westerners or lowland Chinese on the climb. ‘Their tissue oxygen concentration is almost the same as Westerners and Chinese but they are strong,’ he said. ‘And their red blood cell count starts to increase. But Tibetans and Sherpas keep the same levels,’ he said.

EPAS1 codes for a transcription factor. It helps to regulate the expression of other genes. Nielsen said the gene is involved in regulating aerobic and anaerobic metabolism in the body (cell respiration with and without oxygen). ‘It may be that the [mutated gene] helps balance anaerobic versus aerobic metabolism in a way that is more optimal for the low-oxygen environment of the Tibetan plateau,’ he said.

Writing in Science, where the results are published today, the authors say: ‘EPAS1 may therefore represent the strongest instance of natural selection documented in a human population, and variation at this gene appears to have had important consequences for human survival and/or reproduction in the Tibetan region.’

Dr Wang said future research will focus on comparing the levels of EPAS1 expression in the placenta of Tibetan and Han Chinese women.

Source


Let’s start by considering the nature of the study described in the article.

1. Give a brief evaluation of the study described in paragraphs two and three.

Now we will look at the biology in, or connected to, this article. Don’t worry if you are not ready to give answers to these questions yet. You may like to return to the questions once you have covered other topics later in the book. Use the timeline at the bottom of the page to help you put this work in context with what you have already learned and what is ahead in your course.

2. How does having a high red blood cell count help the Peruvians overcome altitude sickness?

3. What is the role of haemoglobin?

4. Explain why many elite athletes spend time training at high altitude.

5. Tibetans typically demonstrate a much higher breathing rate than other people. How might this benefit living at high altitude?

6. The article refers to selection of a gene (paragraph 3). It would be more accurate to refer to a selection of alleles – explain why.

7. The article states ‘a gene that controls red blood cell production evolved quickly’ (line 1). A scientist stated that this was an inaccurate statement. Explain why this may not be accurate and give a more scientifically accurate description of what has happened.

8. EPAS1 codes for a transcription factor. It helps to regulate the expression of other genes. Suggest what effects the EPAS1 gene may bring about that help people survive in places with low oxygen availability.

9. Suggest why researchers will focus future research on EPAS1 expression in the placenta.

Activity

When people climb to high altitude, the physiology of oxygen transport changes to adapt to the lower availability of oxygen. Draw a flow diagram of the path taken by oxygen from the air in our lungs to the muscles where oxygen is used in respiration. Annotate the diagram to explain the role of haemoglobin in transporting oxygen, ensuring that you use correct scientific terms as much as possible. Using a different pencil, annotate with suggestions about where this pathway may be altered or adapted in people who normally live at low altitude but have climbed to an altitude of 5000 m.