ALTITUDE PHYSIOLOGY: LESSONS FROM ETHIOPIA

This article was written by ATMA President Indy Sahota for The Lancet Student in 2010. It chronicles his research experience studying cardiovascular physiology in the high altitude regions of Ethiopia during his M.Sc. studies.

High altitude populations

More than 140 million people live at altitudes over 2,500 m. In certain areas of the world, such as in the highlands of Peru, East Africa and South-Central Asia, some populations live at altitudes over 4,000 m where ambient oxygen availability is a meager 60% of sea-level values (1). By comparison, the peak of the highest mountain in Western Europe, Mont Blanc, is only 4807 m. At these altitudes, even functioning normally is no small feat. Yet for generations these populations have somehow managed to survive in the face of extreme hypoxia, freezing temperatures and low pressure. These three populations, however, have not adapted equally to high-altitude living (3). A theory of migration attempts to solve this disparity by stating that how well populations have adapted to high-altitude is dependent on the time they have been resident there. Understanding the physiology of these populations could therefore yield important implications. Firstly, as many people now ascend to higher altitudes for recreation, determining how the body best copes with hypoxia from populations that have adapted well could help these amateur sojourners cope with the extreme environment. Secondly, understanding the physiology of those populations that do adapt well could help inform treatment on how to help those populations that don't. Knowing this, a research team of physiologists from Canada, the UK and the USA set their sights on the Ethiopian highlands. As an M.Sc. student studying cardiovascular control at Simon Fraser University in Vancouver, Canada it was difficult to say no to the opportunity to be involved in some field research overseas.

The story so far

The team had experience of similar research amongst native high-altitude residents over the past 6 years and over 3 continents. Results from research amongst Highland Peruvians, Tibetans and Ethiopians had shown a spectrum of hypoxic adaptation between the Peruvians who seemed the least-adapted and the Ethiopians who seemed to be best-adapted to the altitude (3). An underlying theory of human migration has been put forward in an attempt to solve this disparity, in proposing that the Ethiopians' adaptation may be due to their residence at such a high altitude for longer; Homo sapiens, after all, are considered to have originated from what today would be Kenya-Ethiopia. Peruvians, on the other hand, would have migrated to their resident altitude much later on in an evolutionary timescale and, therefore, would not have adapted so effectively (4). Chronic Mountain Sickness (CMS), related to cerebral autoregulatory dysfunction, is often used as a marker of mal-adaptation to high-altitude (5) and anecdotal reports were beginning to surface of CMS incidence in an Ethiopian population in the southern Bale Mountains. Previous studies performed in the northern Simien Mountains of Ethiopia failed to find any cases of CMS (2). Given the close proximity of these populations, the above theory would suggest they share a similar genetic makeup and adaptation profile to the high altitude. However, if the reported cases of CMS were in fact true, and we could determine that the two populations differed in cardiovascular responses to the altitude, we would discredit the prevailing migration theory for human high-altitude adaptation.

The joys of high altitude

Our campsite in the Bale Mountains was desolate. At 4,118 m there wasn't much wildlife save some small birds and the odd Ethiopian wolf. The high altitude became more than a research topic as it began to have its effect on me personally: with an ambient barometric pressure of approximately 460 mmHg at the campsite, oxygen levels were about 60% of that at sea-level. Consequently, my blood oxygen saturation had dropped to about 70% and my average heart rate floated around 130 beats/min (compared to 60 beats/min at sea level). A huge headache, nausea, fatigue, lack of appetite and wanting to vomit all welcomed me to life at high altitude. Thankfully, I was surrounded by doctors at the campsite who were able to keep an eye out for the more serious symptoms of the deadly pulmonary oedema and cerebral oedema. Often these two problems affect altitude sojourners and as I had never camped above 1,000 m prior to this trip it was a real worry that had to be addressed. Whilst the rest of the team set up, the only thing I could do was try to sleep and get better as soon as possible; the research would need to begin soon.

Researching above the clouds

Researching on the mountains was hectic. Everyone was up at sunrise and we would be testing continually till sunset. We only had a few days to test eight locals with each test taking about four hours. It was up here that I realized how different field research is to that conducted in labs across the world. All the equipment had to be set up in the morning and taken down at night in fear of animals ruining it. Generators became both our best friends and worst enemies as they often broke down leaving all teams stranded. No power meant there was no way to collect data and out there sticking to deadlines was hard enough as is. Power failures in Bale were a constant problem and oftentimes we would be stranded in the middle of our experiments, already hungry, hypoxic and tired, knowing that we still have another subject before the end of the day. In a makeshift tent on top of an African mountain, maintaining clinical standards became a full-time job. Equipment was constantly being sanitized and cleaned and dirt would somehow find its way into absolutely everything. Up on the mountains it really was machine versus nature. Kicked-up dirt managed to destroy one of the teams' ultrasound equipment and our laptop and gas analyzer were beginning to show signs of trouble. As the temperatures dropped below zero overnight all equipment would collect condensation and at sunrise we would waste no time in taking out the equipment and drying out the components to prevent them from dying as well. Passing on messages to a subject in Bale had to cross three languages beforehand and given the complexity of the Ethiopian languages, learning to pronounce just "hello", "thank you" and "how do you feel" properly took a lot of work. Nevertheless, it really was exciting. The idea that we were studying people that have probably never been studied before with the possibility of finding something new must have been enough to excite any medical professional.

There are important adjustments that, I feel, researchers need to make when working in these environments. Firstly, never expect anything to go to plan. From problems with getting customs approval for our equipment to constant power failures hindering data collection, stalls are the only things that are guaranteed when conducting field research. Secondly, understand the volunteers who are involved in the tests. It is extremely important to understand local customs and viewpoints so as to not offend people in your interaction with them or question why something that is normal to you is not

as normal to somebody else. A lot of this grows out of respect for other people but its importance makes it worth noting in any case. Third and finally, be prepared. Environmental conditions, equipment damage, problems with subject recruitment; there are many factors that cannot be controlled for when operating in the field outside of the laboratory. It is important to be conscious of all the potential challenges and be prepared for them as well as possible.

Cultural issues in overseas field research

Conducting research in a foreign country poses other cultural and ethical issues as well. Informed consent is a particularly important one. Informed consent forms are documents that fully explain the test procedures along with the benefits and possible negative effects the research may have. When conducting human research it is imperative that informed consent is obtained from the volunteers. The problems in Ethiopia were, firstly, the language. The informed consent forms we had for the protocols had to be translated into all of the local languages, which made sense. However, most of the villagers could not read thereby making the informed consent forms largely biased by the way they are interpreted and explained by the researcher. We had independent doctors travel with us to accurately discuss the test protocols in as unbiased a manner as possible, but this is a potentially dangerous loophole that other researchers or medical professionals could exploit as research in these places is not well regulated. Another issue that commonly arose in researching this population was that many locals did not feel comfortable in certain test protocols, notably, giving blood samples. Of course, if locals did not feel comfortable we did not force them and they were welcome to complete certain protocols while leaving others incomplete. The doctors later informed us that many locals see giving blood as giving more than just biological material and that it's almost viewed as giving away part of something more metaphysical. To many of us this was new but, as always, it was important to respect the wishes of the volunteers and so we happily removed those test protocols for the volunteers that were uncomfortable with it.

The locals we were testing were remarkable people. Almost all of them were subsistence farmers and they seemed taller and more muscular than the average Ethiopians I had seen in Addis Ababa. None of the villagers spoke English and my Orominya (the local language) was virtually non-existent, but through one of the Ethiopian doctors travelling with us I was able to talk to a lot of the locals that came up to the campsite. tThey all confused me for being a Muslim, and being Muslims themselves an occasional salaam would make a lot of the elders happy. The few attempts I did make to explain that I wasn't Arab and that my grandparents were from India were futile but I must admit, I thoroughly enjoyed my interactions with the people in Bale. We were generally well-received by the local population we studied although there was an element of trust that had to be built before we reached that point. We noticed in the first couple of days of testing that most of the villagers would bring hunting knives with them to the testing campsite. However, towards the middle and end of our stay they no longer brought them. The doctors had spoken to some of the villagers who told them that they had previously brought the knives for protection to make sure we do not harm them! After they had realized we intended to do no harm they started coming without the knives. Although it at first may seem odd to require protection as we normally trust researchers to conduct ethical research, it makes sense that a people who may have never been exposed to the concept of research before would need to make sure we're not setting out to hurt them. When the locals stopped coming for tests with their knives we took that as a sign that we're doing something right!

Another thing I learnt in Bale in particular, but Ethiopia in general, was that I brought with me many false preconceptions about the place. Thanks to charity advertisements I'd seen back home I envisioned a drought-stricken and poor Ethiopia where almost everybody was starving and urgent humanitarian interventions were needed. However, what I saw in Ethiopia and in Bale were a proud people who worked hard and a country that seemed to be relatively prosperous. Sure, they have faced hardship in the past and as water is such a precious commodity there remains the possibility they may also have to face it in the future, but I was taken aback by the strength of the Ethiopian people and was left admiring the resolve they showed. I can only hope to convey this message to others to help curb any misconceptions they may have of the country and its people.

Conclusions

Although the results of the experiments are still being disseminated we hope that our research may provide many answers for us. Already high altitude field research like ours has helped identify certain drugs, such as acetazolomide, in helping people with CMS (6). As the results slowly begin to surface we also hope to be able to provide a better anthropological understanding of how some populations are better adapted to high altitude then others. Ultimately though, the research is about helping those high altitude populations that suffer with CMS and through better understanding the different cardiovascular and genetic profiles of well-adapted high altitude populations we may be able to confer better treatment for CMS in less adapted populations.

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