EPISODE TWENTY THREE OF "ARMED WITH SCIENCE: RESEARCH APPLICATIONS FOR THE MODERN MILITARY," A DEPARTMENT OF DEFENSE WEBCAST HOST: DR. JOHN OHAB GUEST: DR. STEPHEN MUZA, MOUNTAIN MEDICINE TEAM LEADER, THERMAL & MOUNTAIN MEDICINE DIVISION, U.S. ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE TIME: 2:30 P.M. EDT DATE: WEDNESDAY, JULY 8, 2009

ANNOUNCER: "Armed with Science: Research and Applications for the Modern Military" is a weekly webcast that discusses cutting-edge science and technology and how they apply to military operations.

Each week we will interview scientists, administrators and operators to educate and inform our listeners about the importance of science and technology to the modern military.

DR. OHAB: Good afternoon, and welcome to Episode 23 of "Armed with Science: Research and Applications for the Modern Military." I'm your host for today, Dr. John Ohab. I hope you're having your best day ever. We're joined this afternoon by Dr. Stephen Muza, Mountain Medicine Team leader, the Thermal & Mountain Medicine Division at the U.S. Army Research Institute of Environmental Medicine.

Dr. Muza will discuss the impact of the thin air of high altitude on conducting mountain operations and explain how the Army is using science to improve warrior health and performance at high altitudes.

Dr. Muza, it's a pleasure to have you here this afternoon on "Armed with Science." How are you?

DR. MUZA: Good afternoon, John. I'm feeling well. We got a little bit of sunshine up here in the Boston area and I'm looking forward to the interview.

DR. OHAB: So are we. A quick reminder to our listeners. As always, if you have any mountain medicine-inspired questions, you can Tweet them @armedwscience, or you can post them on our show page, BlogTalkRadio.com/armedwithscience.

Dr. Muza, from the standpoint of the ground warrior, how would you define high altitude?

DR. MUZA: Well, we use a variety of definitions to decide, or metrics, I should say, to decide where the threshold for high altitude is. In our current guidance, we define high altitude as starting at 1,200 meters above sea level, or approximately 3,940 feet.

By the time you have ascended to this altitude, there are very measurable decrements in prolonged physical work performance, especially also what we call our VO2 max, or maximum aerobic performance.

And as you proceed higher, straight up above 7,000 feet or 2,400 meters you start to actually start to encounter the possibility of developing altitude illness, and of course the higher you go, the bigger the impact on your work performance and the greater likelihood of developing altitude ailments.

So, for our purposes, 3,900 feet, 1,200 meters is the floor of high altitude.

DR. OHAB: We're going to talk a little bit more about altitude sickness as the show goes on. Can you describe some of the specific challenges that high altitude presents to military service men and women?

DR. MUZA: Well, as I've already indicated in the definition of high altitude, you know, one of the significant impacts that starts at a relatively modest altitude is the decrease in the physical work performance, specifically what we call aerobic performance, typical of military operations, not necessarily short sprints or even strength. Muscle strength is not negatively impacted by high altitude and the ability to, let's say, run a very short distance at high intensity is not particularly impacted. But if you have to maintain a prolonged work such as an approach march or patrol, particularly with a heavy workload such as carrying a heavy load, that's going to have a significant negative impact.

Usually what happens is you have to slow down. And the reason for this is, as you go higher, your ability to perform maximal work decreases, but to carry that load, that doesn't change. And so the percentage of your max work that you have to perform increases with increasing altitude and you simply reach a ceiling or a limit where you can no longer sustain that task, and the choice of either to slow down or you're going to have to take -- you're going to fatigue sooner and take more rest breaks.

As you get above 10,000 or -- well, let's take it in this order: As you get above roughly 7,000 to 8,000 feet altitude, you start to see the development of altitude sickness, especially acute mountain sickness. And that is a headache, light-headedness, nausea, could be vomiting. And although mild symptoms may not cause much of a problem, moderate to severe systems of AMS could basically ground you and you wouldn't be able to perform your work.

And then when you get above 10 (thousand) to 12,000 feet, we really start to see cognitive performance deficits. You ability to make a decision is impaired. In particular, it takes longer to arrive at the decision, especially when you're trying to assemble new information.

So those are some of the challenges presented to the military when they start to work at high altitude.

DR. OHAB: And, Dr. Muza, as I mentioned earlier, you work within the Thermal & Mountain Medicine Division at the U.S. Army Research Institute of Environmental Medicine. Can you tell us a little bit about your institute and the kind of research that your team is conducting?

DR. MUZA: Well, yes. Our institute is our subordinate laboratory of the U.S. Army Medical Research Materiel Command, which is headquartered out of Fort Detrick. And as you indicated, our mission is pretty much in our name.

We conduct research into environmental medicine and occupational work, or physiology and nutrition research, all of this specifically to identify problems that the warfighter would encounter in the environmental extremes of heat, cold and high altitude, and across a wide spectrum of military tasks.

Our institute was founded in the mid-'60s. Basically at that point there were several small laboratories scattered throughout the U.S. Army that were doing environmental medicine and occupational work performance studies, and they were all brought together under one roof here in Natick, Massachusetts.

We're co-located with the U.S. Army Soldier Systems Center, and that's primarily an Army Materiel Command facility whose mission is to develop uniforms, protective equipment and rations for the warfighter, and we share -- between the two groups here we share a variety of environmental chambers. We can reproduce arctic cold, desert heat, tropic heat and humidity.

And specifically, with regard to our operations, we have an altitude chamber, or hypobaric chamber, in our facility. It's a nice, large chamber about 900 square feet. We can adjust the altitude between sea level and up to about 9,000 meters, or roughly 30,000 feet.

And we also have complete control of the environment in there, including the temperature and humidity. So we can do -- simulate the summit of Everest or a high desert environment, which is very common to Afghanistan.

We also have -- in addition to our altitude chamber, we own and operate a laboratory facility on the summit of Pike's Peak, Colorado. This is the highest road-served mountain in North America. It's -- we are just about an hour's drive west of Colorado Springs.

Our laboratory has been on the summit of Pike's Peak since about 1966.

And at the laboratory we can set up and operate a laboratory with all of the capabilities that we have here back in Natick. In addition, we have a dormitory to house about 18 test volunteers, kitchen facilities, obviously restroom facilities and such for both subjects and staff.

And, in addition to the laboratory, we have access to the Pike National Forest and the surrounding terrain. So we have conducted studies from roughly 7,000 feet at the base of the mountain all the way up to the summit of the mountain at 14,000 feet.

So that gives sort of a broad background to the kind of work that we do here at the USARIEM.

DR. OHAB: And give us a sense of the scientific disciplines that are involved in this kind of research, as well as your own scientific background.

DR. MUZA: Well, first, speaking from the institute's perspective, we have -- we range from molecular research where we have individuals who are trained in molecular biology, proteomics, genomics, doing studies on both cell culture -- you know, Petri dishes -- and small animals such as rodents, all the

way to the human, which is my particular area of expertise -- or systems physiology, integrated physiology.

And we -- many of us are physiologists. There's also nutritional scientists, biomechanical scientists. We have a number of mathematical or physical modelers in our discipline, statisticians. We do a lot of biochemistry work.

Even in our work we frequently study human adaptation to high altitude by looking at changes in hormone levels and other markers and signals within the body. So we cover everything from molecular biology all the way to integrated systems physiology.

We use as -- many of our measurements are focused on work performance. After all, the military is there to do a job, and that work performance could be in the area of physical performance such as carrying loads, performing a particular physical task. It could be cognitive performance. And in fact, I forgot we have, you know, research psychologists on board, whose job is to look at that aspect of performance.

We also have laboratories that are unique to military tasks. We have a relatively new laboratory which essentially duplicates a simulation of marksmanship. It could be presented using virtual reality-type operations. Soldiers or test volunteers can be presented with situations in which they have to make decisions about identifying friend or foe and in fact engaging a target.

And we can stress these individuals out by sleep deprivation or various types of -- maybe depriving them of food or rations like may be common in a military situation, and then look at ways to intervene to improve their performance.

So we involve -- you know, we use both tasks that you would find in a university laboratory, well respected and accepted scientific approaches to measurement of human performance, and we also use tasks that are unique to the military.

DR. OHAB: And you had mentioned the role of volunteers. Where do you actually find your volunteers, and what are some of the activities that that entails?

DR. MUZA: Well, the majority of our human research volunteers are military personnel. Most commonly we have a group here at the institute and at the facility across the street where they will go to typically U.S. Army forts where there have been basic combat training and advanced individual training, recruits who may have a few months on their hands before they're being assigned to a unit.

And rather than them hanging around that particular fort, those individuals will frequently be approached and asked if they would be interested in participating in our human-use research studies. They're given a briefing about the nature of our work. It's completely voluntary.

And if they're interested, they're determined to be physically fit and qualified to participate, then they will come up here to USARIEM on temporary duty for usually three months, sometimes up to six months. And at that point they have the -- they'll be briefed on a specific study, and if they're interested they can volunteer to participate in that study.

In addition to that type of recruit we also sometimes will get a specific request from maybe the U.S. Marines or Special Forces to test some product or some item relative to their own forces, in which case we'll go and we'll recruit from their bases.

And we frequently use civilians. In particular, we use young civilians, typically in their early 20s, common to the U.S. military. They have to be physically fit and capable of the same kind of fitness standards and medical standards that would be appropriate to a military person.

But especially when we need to do long-term studies, studies that may involve nutrition or physical exercise training, that may require participation for four, five or six months or longer, then commonly we use the civilian recruits from the local area.

DR. OHAB: Now, clearly it's important that service members can avoid the negative effects of high altitude. What has your institute done to improve procedures to facilitate altitude acclimatization?

DR. MUZA: Well, acclimatization is the best way to adapt to high altitude, and for centuries it's been known that if you rapidly ascend particularly above 6 (thousand) or 7,000 feet, you're likely going to suffer problems associated with the high altitude, especially the acute mountain sickness.

And our guidance has been to ascend slowly, or that means above 6 (thousand), 7,000 feet, ascend no more than about a thousand feet a day. Or an alternative is to ascend up to let's say 7 (thousand) or 8,000 feet and stay there for approximately a week, at which point then you will have adapted -- or physiologically adapted to where you can ascend higher much quicker.

These are well-known approaches, and what we've been doing particularly over the last several years is trying to quantify the exact amount of improvement that you obtain for a given number of days of acclimatization.

For example, recently we've completed a study -- and some of this is now coming out in publication, where we took soldiers residing here in the Boston area essentially at sea level, and we transported them by commercial aircraft to Colorado Springs and had them reside at the Air Force Academy at approximately 7 (thousand) feet above sea level for six days.

And while at the academy, we kept them physically active like a military unit would be, and then by car we took them directly to the summit of Pike's Peak, Colorado at 14,000 feet and tested them over the course of the next five days.

And what we found is, compared to -- if we had taken them directly to the peak, we found that the individuals who had just spent six days at 7,000 feet had very little acute mountain sickness. They had very substantial improvements in their work performance at that altitude. Or another way of saying it is the decrement in their work performance was far less than if they had rapidly ascended.

So now we know that six days at 7,000 feet is very effective. Our next step is probably to reduce that another two days or three days. And so the question is, what's the threshold? Is there days going to provide what

percent of improvement, or four days? So that's one of the approaches we're taking with the acclimatization.

DR. OHAB: What about medications? Are there any medications soldiers ascending to high altitude can use to improve health and performance?

DR. MUZA: Well, within the United States the only FDA-approved medication for prevention and treatment of acute mountain sickness is acetazolomide, which is sold under the trade name Diamox. And it's an effective medication, but one of the negative problems with its use is that it has some side effects. Although relatively mild, they can be a little disturbing.

It causes a tingling sensation in fingers and toes and even in your nose. It erupts your taste buds, and so carbonated beverages taste metallic and such. It also, when taken in slightly -- in higher doses can actually impair physical work performance. So your ability to sustain that rough march could be degraded even though it's protecting you from acute mountain sickness.

So that drug is out there. It's in the stockpile and accessible by the U.S. military. Some other medications that have been proposed could be effective, and we've studied some of them.

Recently we looked at whether or not erythropoietin, which is normally used to stimulate the increase in red blood cell production -- we recognize from animal studies that it has some potential neuro- protective effects. It may in fact prevent the cognitive performance problems at high altitude and decrease acute mountain sickness.

That study we just concluded. We're writing up the results, but our work indicated that at the dosage levels that we used, that this did not produce a protective effect. We do not develop new medications here, but what we do do is we scan the literature and we look for emerging new pharmaceuticals that may have beneficial impacts, and when we identify those, then we design the appropriate studies and conduct them. So that's an area -- in fact, there is a very big interest right now in whether or not you can induce altitude acclimatization by taking your medicine.

And there is some emerging data that suggests a class of new drugs, which have yet to be tested in humans under the conditions of altitude exposure, that they may in fact -- while you're residing at a low-altitude base, taking this medication for two, three or four days prior to going altitude may in fact induce acclimatization so that when you arrive at altitude you're in much better shape to conduct your duties.

DR. OHAB: That's probably well understood that what one eats or drinks is going to impact their performance on the ground, but to sustain performance at a high altitude, do soldiers need to change their diets?

DR. MUZA: Well, not so much change their diets as, if possible, maintain a good diet. One thing we do know about altitude is when you go to high altitude, you still need to produce the same amount of ATP, the energy used by the body, your muscles in particular, to conduct the tasks that you needed to perform.

The most efficient production of ATP is from carbohydrate. And so there is data and evidence out of our lab and others to show that carbohydrates are the preferred fuel at high altitude, and we encourage, and in fact in our

published guidance we indicate that a diet that maintains at least 60 percent or more carbohydrate is the way to go.

We also have demonstrated, about two years, three years ago, a published work out of our laboratories demonstrating that an individual who rapidly ascends to 14,000 feet and then has to perform prolonged physical work on the order of 90 minutes to two hours, that by taking -- consuming carbohydrate in a liquid beverage about every 10, 15 minutes, that they perform that work 25 to 30 percent better than an individual taking placebo. So it's clear that carbohydrates are the best fuel to use in altitude conditions. And that information that we discovered with regard to physical work performance has now been translated into a new ration.

The folks across the street at the Soldier Systems Center have developed what they call a Modular Operational Ration Enhancement, or MORE, and it specifically includes a large number of carbohydrate- based snacks so that the soldiers and warriors in the field could quickly grab and consume some carbohydrates and continue to do their mission.

DR. OHAB: So are your findings being utilized or translated into use by other services besides the Army?

DR. MUZA: Well, yes. Although we're an Army laboratory, we are the, as they say, the executive -- the Army is the executive agency for environmental medicine research within the Department of Defense, and to that extent we work for all of the services. And in fact, we frequently go out and give talks and meet with representatives from the Navy, the Marines.

I was recently out at the Marine Mountain Warfare Training Center in Bridgeport, California, which is really the U.S. military's premier mountain warfare training center, but again, it's operated by the Marines, but they have all services come through there.

We have close connections with the Mountain Warfare Training Center in Vermont, with Special Operation forces, which are all of course combined commands. We have interfaces with the Air Force extensively. So we operate for all the services.

And one of the key ways we get our information out is through publication. Of course, we all publish our work in peer-reviewed scientific journals, and that validates the quality of our work, but we then turn around and will write the results of our work up in language that is used by the Army Medical Department and other medical service departments for the development of their own policy and guidance.

And one of the key publications -- we have one that's currently in the process of being published -- is what's called a technical medical -- a Technical Bulletin Medicine, or TB MED, and the one for altitude acclimatization and illness management that we've recently written will probably be published later this year by the Department of the Army.

DR. OHAB: As we wrap up today's show, do you have anything else you'd like to add, any websites you'd like to send people to?

DR. MUZA: Well, if you are interested in further information about the U.S. Army Research Institute of Environmental Medicine, you can go to our

website, www.usariem.army.mil. And at that website you could learn more about our institute. You can also download some of our publications.

If you have a question about environmental medicine or occupational physiology in medicine, nutrition, you can submit a question through the website and it will be forwarded to a subject matter expert here at the institute.

So we encourage any of our military personnel out there -- civilian, military, whatever -- from all around the world, if they have questions of this sort, please contact us.

DR. OHAB: Dr. Stephen Muza, Mountain Medicine Team leader in the Thermal & Mountain Medicine Division at the Army Research Institute of Environmental Medicine, thank you again for taking the time to be here on "Armed with Science."

DR. MUZA: You're welcome, John. Have a good day.

DR. OHAB: You too.

Listeners, please tune in next week when we are joined by Dr. Sujeeta Bhatt, research scientist at the Defense Intelligence Agency, who will discuss the neuroscience of deception. Dr. Bhatt will discuss deception detection methodologies and research, with a specific focus on neuroimaging techniques.

Thanks again for listening. I'm Dr. John Ohab, and you have been scienced.

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