EPISODE EIGHTEEN OF "ARMED WITH SCIENCE: RESEARCH APPLICATIONS FOR THE MODERN MILITARY," A DEPARTMENT OF DEFENSE WEBCAST HOST: DR. JOHN OHAB GUEST: DR. CLAIRE GORDON, SENIOR SCIENTIST IN BIOLOGICAL ANTHROPOLOGY AT THE ARMY NATICK SOLDIER RESEARCH DEVELOPMENT AND ENGINEERING CENTER DATE: WEDNESDAY, JUNE 3, 2009

NARRATOR: "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 18 of "Armed with Science: Research and Applications for the Modern Military" on Wednesday, June 3, 2009.

I'm your host for today, Dr. John Ohab.

We're joined today by Dr. Claire Gordon, senior scientist in biological anthropology at the Army Natick Soldier Research Development and Engineering Center. She'll discuss the Army's research on body size and shape variation, otherwise known as anthropometry, which impacts the design and sizing of virtually everything a soldier wears, carriers, flies, drives, works at or lives in.

Dr. Gordon, thank you for being here today with us on "Armed with Science". We really appreciate it. How are you?

DR. GORDON: Oh, I'm great! Thanks for having me.

DR. OHAB: A quick note to our listeners: If you have questions, please Tweet them to @armedwscience or you can post them on our show page blogtalkradio.com/armedwithscience. Dr. Gordon has offered to answer those questions, so please do not hesitate to take advantage of this opportunity.

Dr. Gordon, anthropometry -- other than a word that I am going to have difficulty pronouncing with consistency today -- what is anthropometry?

DR. GORDON: Well, it's the study of body size and shape and portions -- things like length, breadth, depths, circumferences, surface areas, body curvatures, volumes -- even mass distribution properties of body segments. It's got a wide application.

In the medical fields, it's used sometimes to assess nutritional status or growth and development. And it's used extensively in surgical repair and reconstruction.

It has forensic application -- for anybody who watches "CSI" or "Bones", you'll know that the identification of unknown persons sometimes relies on body measurements. You can do age-progression drawings of missing children. And even accident reconstruction relies on anthropometry.

Probably what's best known for the military, though, is the human engineering anthropometry. And in that case, the measurement of the body and the study of body measurements in general, and shapes, is used to guide the design and sizing of everything from clothing to equipment, aircraft -- anything a soldier wears, carries or drives. And it has broad application in the civilian world too.

DR. OHAB: And we're going to get into that a little more as the show goes one.

Let's talk specifically about the Army. Why is the Army investing in this line of research?

DR. GORDON: Well, as you can imagine from your own experiences in life, the clothes that you wear affect how you feel, how you perform. The cars that you drive -- if you can't see over the steering wheel or you can't get a good view over your shoulder or the seatbelts don't fit right, it really bothers you. It bothers the way you function.

And in the Army, that's very important, because our guys and gals are not just doing it in every day life, when they work they're exposed to extreme climates and physically threatening conditions. So if something doesn't fit well, it actually affects their safety. So it's a real issue for the Army.

In addition, the Army has a responsibility to be very efficient in its sizing. We can't have lots of more sizes of each thing than we need, because it costs taxpayers extra money to have things on the shelf. So we've got to fit the soldiers well to keep them safe and keep them performing well. And we've got to do it in an efficient way so we don't waste tax dollars.

For that reason, the Army's had anthropologists like myself working for them since World War II full time.

DR. OHAB: So could you contrast how the Army functions, perhaps, with commercial vendors? What does the Army do different in its sizing?

DR. GORDON: Well, one of the important differences is that commercial vendors really don't try and fit everybody on the street. A commercial vendor will choose a market to fit -- a subgroup of the population -- and say, that's my target market and I'm going to fit that group.

So for example, some of you who are very short -- like me, I'm five-foot-three -- find that certain brands of cars fit us better than other brands. And that's because they're marketing for us. And for me, in particular, Japanese cars -- especially 10 or 15 years ago -- were the only ones that really fit small people so I had a preference for that.

But the Army, see, is required to accommodate at least 90 percent of its population off the shelf with no customized sizing. And that's for clothing and equipment. For life-protecting equipment, as much as 98 percent of the people we have to fit off the shelf. So it's not like if you could just go from

one store and walk three doors down and get something that fits better. You've got a one-stop shop and we've got to fit everybody.

They're serious too. Fitting issues aren't fashion problems and they aren't just annoying. They're safety problems. And often in civilian life, we tolerate like poor fit pretty much routinely. And for the commercial vendor, the bottom line is, are they losing money? So if they don't fit anybody very well, until they lose money, it's not an issue. They're not going to spend money on improving that.

So if they're getting a lot of returns if they're a catalogue company, they might be interested in anthropometry or if they're losing customers they might be interested in anthropometry or if they're getting lawsuits because things don't fit and there are accidents, they're very interested in the anthropometry. They really don't invest in that as a science at all. So that's another difference.

The Army invests in it. Poor fit means safety. It hurts performance and our ability to defend the country. So it's an investment the Army makes.

One of the other things that's really different is the Army's a very diverse population. We have more minority groups in our work force than most other kind of occupations do. And so we're very interested in fitting minority subgroups who might have body sizes and shapes a little different from the majority. And it's just as important to us that we fit them well and make them safe as it is for the majority. So we use slightly different statistical methods in all of our sizing.

DR. OHAB: Now, with this interest on anthropometry in the Army versus a commercial vendor explain why a person that's say, my size, 6'2", be so uncomfortable on a plane?

DR. GORDON: Yes. (Laughs.) Well, obviously, the people that are making decisions on the planes are not sitting back in coach class, are they?

It's a very good thing -- I mean, you bring up a really important point. With science, with all sciences, scientists tend to do research that's focused and bounded. And when we actually try and transition that research into complex systems, then we have to make tradeoffs. And that's an example of a tradeoff in which, obviously, the aircraft people have decided that the cost of fuel is very high on their list of things to minimize. And so they will pack as many people in as they can without actually prohibitively -- making the seats so small that they're prohibitively small.

DR. OHAB: Dr. Gordon, you're a senior scientist at the U.S. Army Natick Soldier Research Development and Engineering Center. Would you tell us, first, a little bit about the center and then your position?

DR. GORDON: Right. Natick is located about 20 miles west of Boston. It's a pretty exciting place to work, because we focus on survivability of the individual soldier, sustainability of the soldier and mobility. So clothing -- all the clothing and equipment items for soldiers are developed here and also the food systems are developed for all three services here. And we're responsible for individual and equipment airdrop systems and organizational shelters. It's a pretty, as I said, a pretty exciting place to work and we're all pretty motivated, because it's all about the individual soldier.

We have some key partners that we work with here at Natick on the post. The U.S. Army Research Institute of Environmental Medicine, which does skin types of research; and the Navy Clothing and Technical Research Facility is here as well -- and we have the integrated logistics center so we can work from cradle to grave with our partners.

And it's the home of the Army's anthropometric database since 1954. So Natick has had a database of Army soldier measurements since World War II that's maintained there. We update it periodically and we provide those data to all the Army applications and all the other Army REDECs. For example, if you take an automotive command -- it uses our data.

So that's what we do at Natick. Our database right now is comprised of about 132 body dimensions on more than 9,000 soldiers. And we have whole body scans and heads and faces as well.

And what I do is I'm one of about seven physical anthropologists/biological anthropologists that work here at Natick. I'm a senior research scientists, which means that at this point, I'm expected to spend most of my time pushing the state of the art in my field of research.

Nobody here gets to do research 100 percent of the time -- even though we're supposed to; that's a fantasy for any of you out there listening -- but it definitely -- pushing the state of the art is part of my job description. Transitioning my science to practice is extremely important. So I spend a lot of time translating engineering problems of fit and design back to anthropometric problems and then solving them statistically and transitioning those results back to the engineers or clothing designers for their products. And that's a lot of fun. I've enjoyed that a lot.

I'm also mentoring scientists and engineers here as a senior scientist on their careers. And I advise the senior leadership on scientific issues. And although I'm stationed here at Natick, as a senior professional, I'm actually a Department of the Army asset. So I also consult with a lot of the other Army research functions and I consult with DA with their spending of money in basic research areas.

DR. OHAB: And one thing you mentioned was the idea of translating some of this research into practical applications. And that was something that Dr. Schmaljohn last week mentioned regarding her DNA vaccines. It seems like that's a theme there with the Army research.

DR. GORDON: It is. You know, we do basic research here. And when we do basic research, you may not know what the application is. But in my areas of anthropometry, mostly what we do is maybe 10 percent basic research and 90 percent applied research and development.

And basically, you look at problems that are happening in the field and you say, oh, this problem -- this fitting problem, the sleeves are too short on this item. And oh my, the reach is not enough on this work station. And what is it? Somebody's -- you look for a commonality in which the problem, the scientific problem, resurfaces in different places. And that defines your next basic research front here, basically.

So for example, when I came onboard with Natick in the 1980s, we had just gone to an all-volunteer Army and had an influx of volunteers from minority groups in large numbers. And they had body proportions that were different from

the primarily white males that we designed for in the 1940s and '50s. And as result, many things didn't fit well and I started to see the same mismatches between Army materiel and body that I knew were maybe correlated with racial ethnic subgroups. And so I was able to do the research in the late '80s that gave us a baseline of data to describe those differences and ensure that our minority groups were accommodating in our design criteria. That was pretty exciting!

DR. OHAB: So what are some of the projects that you're currently working on now?

DR. GORDON: Well, yeah -- (laughs) -- nobody does just one thing in the Army. What I'm working right now are two very huge projects.

The U.S. Marine Corps and the U.S. Army are both planning new anthropometric surveys of their population. The last Army survey was done in 1988 and the last Marine Corps effort was in 1994. Since those periods, we've had an increasing difference between the components and between the services. And we've had a change in Army anthropometry in the last 20 years. So we're having to update both of those databases.

So those are the big things. And those are huge efforts. You're literally measuring thousands of people for hundreds of body dimensions and you're having to use a multi-stage, stratified random sampling strategy to pull the people that you're going to measure.

And what we'll do is we'll build databases for those two groups and then those will be used for the next 10 or 15 years to design virtually everything that we buy off the shelf or design from scratch.

And when you look on the TV right now, pretty much anything you see on the TV that's associated with a soldier, was built on the database that I created in 1988.

DR. OHAB: Wow! DR. GORDON: And the database that we're going to be doing now in the next few years for the Marines and Army will serve the whole next generation of warfighters.

So that's a pretty exciting kind of opportunity. And it's the kind of study that you couldn't do in academia. It's one of the reasons that people like me like to work in Department of Defense is that you're able to do huge studies that are pretty complex in your career that you wouldn't maybe get to do elsewhere.

But that's just one event. I'm also working on the statistical methods to better accommodate minority groups in ergonomic design criteria. And I'm not only working on the statistical methods themselves, but I'm working with the International Standards Organization, ISO, to translate those methods into commercial standards so that they'll be able -- they'll be available for improving general ergonomic design criteria and making accommodation more universal.

I'm also working on improving the quality and reliability of body dimensions that are obtained from automated scanning systems like the kind that you can use to have customized blue jeans made or something from Levis.

So those are three big areas I'm working in right now.

DR. OHAB: How do you actually coordinate the data collection process for all these different body size and shape measurements?

DR. GORDON: How do I coordinate the data collection?

Well, usually, you know, you have a lot of body measurements -- about 100 or so, say. And what you do is you sort them into groups of about 10 or 15. And you put them in together so that you don't have to change the position of the soldier very often. So you put all the seated dimensions together, for example. And you then separate the large group of measurements up into about 10 stations. So a soldier would visit each of 10 measuring stations and get different measurements taken at each one.

And then you'd get -- you'd only train your measurers to measure that subgroup at one of the stations. So if you're a measurer you only measure 10 or 15 the entire time of the survey. And that means that you get very good at just measuring those measurements and your error gets very, very low. And in fact, the observer error data that we collected in the 1988 survey indicated to us -- and we published this -- that a trained technician who measures every day a small subgroup of measurements can have less error than even the experts like myself who've been doing this for decades. So it's astonishing!

DR. OHAB: Wow.

DR. GORDON: Yeah. So basically, you screen a large group of soldiers. You select by age, sex and race randomly -- a subgroup of that to have full-body measurements. And they're transported to a measuring site. And they pass through each of these measuring stations and have coffee and doughnuts and hear about engineering anthropometry and we hear about their sizing and fitting problems in the field. So we get a pretty interesting experience. DR. OHAB: Now, you've talked a little bit about the consequences of ill-fitting uniforms in the military. What about some of the nonmilitary applications of this work?

DR. GORDON: Oh, they're everywhere! The most obvious ones right off the bat are firefighters and police, because they need protection and they're in extreme environmental conditions. But it effects everything.

The Army is one of the few organizations that can afford to collect really comprehensive data for engineering. So commercial sports equipment companies, automobiles, aircraft, ships, medical equipment, individual protective equipment for industrial use. All these companies call us and are able to get copies of the military data to use in designing their products. So it affects a lot of things.

Think of like welder's gloves, construction industry uses a lot of protective equipment. The industrial work station are all designed with military anthropometric data. And you know, your earthmoving machinery -- all of those work stations are designs with anthropometric data.

So we can -- I respond to about between 10 and 30 calls a month with -- just out of the blue with people saying, hey, do you know anything about this measurement in this subgroup? And then I can -- either we have the data or I know who has the data and we can help them do that -- help them find what they need.

DR. OHAB: So talk about shape and size in the general population over time. If you were to extrapolate from what we see in professional sports, for instance, it appears that people are getting bigger. Is there any truth to this?

DR. GORDON: Well, yeah. That's what you call secular trends. When a population gets slightly larger each generation it's called a secular trend. And the U.S. population had large secular trends early in the 20th century primarily due to increases in nutrition and health care. And what this is is essentially each generation then achieving more of their genetic potential in their height.

And we still do see some increases in overall body size for our recent American immigrant groups like Hispanics and Asians. However, for our American white and black subgroups that have been in this country for many generations, the increase with each generation has slowed quite a bit.

And really, the biggest change in American body size recently is not an actual increase in body size -- meaning skeletal frame size -- it's an increase in body fat. And I'm sure that many of our listeners have heard about the obesity epidemic that we have in the country. And we see that even to a lesser extent in our military populations. An increase -- large increases, relatively speaking, in body weight over the last 20 years without much increase in height.

Now, that's an interesting thing. The basketball player phenomenon: You look on the court and you see all these really, really tall people and wonder, my heavens, are we increasing a foot every generation or something? Compare the guys now to say 20 years ago.

But what we're looking at there is just a little bit different. We have global economies now. We can recruit and transport players from all over the world. And Yao Ming is a good example of that. From a small village in China he comes all the way to play professional basketball. But we're not actually seeing the general population of the world increase that great in height. We're just seeing them collected in the same place, because basketball is improved by tall players.

DR. OHAB: So in terms of the military outside of the Army, how is this work being applied to those services?

DR. GORDON: Well, it's an interesting story. In fact, the U.S. Air Force maintains biological anthropologists full time, just like the U.S. Army does. We used to actually have a single group in the Army Air Force back in World War II.

And when the Army and Air Force split, the anthropologists -- who, by the way, were all graduate students from Harvard initially -- some of them stayed at Patterson Air Force Base with the Air Force to help design cockpits. And the others that were working on clothing and equipment moved to Lawrence, Massachusetts with the quartermaster corps -- the Army Quartermaster Corps.

So we've maintained -- we have both a historical common origin, but we maintain close relationships with our Air Force anthropology colleagues. We share data. For example, some of the recent Air Force aircraft and clothing has used some of the Army or leveraged some of the Army data and just adjusted it for the population of the Air Force.

And we're -- actually, the Air Force anthropologists will be visiting just this week to talk about female body armor and the shapes that we need to improve the quality of female body armor. So we work closely with them.

We also provide data, obviously, to the U.S. Marine Corps and advise them on their anthropometry in their sizing and design. They have infantry -- an infantry function, which is very similar to a large part of the Army. And so we share a lot of common R&D problems with them. And the Navy has off and on had anthropometric specialists and we provide support to them as required. So all the services work together in this area. It's a pretty small community that does engineering anthropometry. And probably what's less obvious is that we have large international collaborations with other militaries for joint operations, to leverage data and methodology. And we work in both civilian and military standardization groups in order to share anthropometric expertise.

DR. OHAB: Now, you mentioned earlier that you are now a senior scientist.

DR. GORDON: Right.

DR. OHAB: What did you do in school to prepare for your job and what kind of career path did you take to get to this position?

DR. GORDON: Well, you know, I don't think I ever imagined that I would work for the Army when I was younger. I was very interested in biology and mathematics. And I was -- my undergraduate degree is in biology. And I took two years of mathematics. I was a math major before I switched to biology and I was always interested in problem solving.

But I was trained originally as a human osteologist and a paleopathologist. So I did in my graduate work and in my initial work did field work. I excavated burial mounds, looked at the anthropometry of the people, looked at the diseases and the health status of the people and I became interested in human genetics and living people's anthropometry in a post-doc position when I was studying the Hutterites and their anthropometry and genetics at Northwest Medical School.

So I really was preparing for a career as a professor -- a professor of biological anthropology. And I just had a background in human osteology and anatomy and statistics. And what happened was really an accident of fate. As I finished my doctorate, there were no tenure track positions opened that year for biological anthropologists with my specialty. And so I had a choice between either looking at alternative kinds of employment or having a one-year appointment at a university where I'm taking someone's place while they go on sabbatical or something. And I was married to a physical anthropologist who hadn't finished a dissertation yet. So the choice was easy! I got a job.

And the job was with the U.S. Army Natick. And they needed a physical anthropologist to manage their database. And I thought, oh, I'll come to Natick and I'll stay a year or two and I'll do some research and I'll get some publications back and then I'll just trot right back to academia and be a happy camper.

And lo and behold, what happened was when I got here, the problems were so interesting in terms of their applications. At the time we had just -- in the early to mid-'80s -- moved women from the Women's Army Corps, which they

disbanded, and integrated them into the occupations and units that had men in them. And all the equipment that they needed was originally designed and sized for men.

And so what they did initially to accommodate was to scale down these male shapes to female smaller sizes. But I mean, anybody who could listen and just imagine the shape of a man and the shape of a woman. And if you think of a man, you can think of like an inverted triangle with big, broad shoulders and narrow hips. And the female's just the opposite. And you know if you try and scale down that inverted triangle with the big shoulders and the little hips -- scale it smaller and smaller and smaller -- you're never going to get the female's narrow shoulders and broad hips at all. So we had a lot of sizing and fitting problems that were really fascinating.

And I never knew at the time -- because you don't learn engineering anthropometry in departments of anthropology. They don't teach it. It's something that you learn on the job. You come with skills, but you learn on the job. So I just got really enthralled by that and then I had an opportunity to do that 1988 anthropometric survey and do a sophisticated sampling strategy that I would never gotten -- been able to effect in a civilian population. And it just -- the opportunities to make an impact are so great that I stayed. So it was an accident that I got here, but staying is no accident at all.

And I guess I would say if you're interested in this kind of work that, you know, science and math are the bottom line and good communication skills, because you have to be able to describe how your research is going to improve a situation before someone will fund you. And get early research experience as an undergraduate. So research with your professors.

DR. OHAB: Good -- great point.

What would you say is the most challenging aspect of this work?

DR. GORDON: Well, yeah -- it's all challenging. It's one of the things I've like about -- it's kept me here, as a matter of fact.

But in terms of -- there's two things that I think are really challenging. One is the interdisciplinary nature of engineering anthropometry.

You know, as an anthropologist, if there's a problem in the field say with the way a work station in a vehicle works -- whether it fits small people, for example. Well, I can do the math; I can do the statistics; I can optimize the envisioned crew space. But to actually fix it, I've got to team with all these people whose backgrounds are so different.

And so you're dealing with electrical engineers and you're dealing with clothing designers -- all of these people, each of whom has a different perspective than you do. They have a different level of expertise and you've got to be able to bring everybody's expertise to the table to solve the problem.

And so to me, that's the most challenging thing is learning to listen to people with different backgrounds and appreciating that we all have different perspectives.

I mean, for example, for me human variation -- variation in body sizes and shapes are fascinating and they're exciting and they're wonderful. To an engineer, variation in sizes and shapes means that there's problems that the

price control has to take care of. So we come from different points of view and it's really -- it's challenging and it's also a lot of fun.

The other challenging aspect, I think, is dealing with the perceptions of people -- not just the people I work with in the military, but everywhere -- that anthropometry is really low tech and basically (sizing's ?) a trivial problem that anybody can solve. And people think that and they don't want to either spend the money to actually do the really sophisticated multi-variant statistical analyses that we do or they don't want to wait for it. They just think, oh, I'll go buy this off the shelf. It's cheaper, faster, blah, blah, blah. So we're constantly being challenged to justify our science, basically. Why is science needed to do this?

And that's a big challenge and it's not something you would think about normally. In academia it's assumed that research is needed to push the state of the art. But in an applied setting, the fact that you would propose to do a very rigidly defined or a high quality scientific study to answer a very dirty problem is not intuitive at all. So being able to communicate that is a big challenge.

DR. OHAB: And I know you've won a number of awards for your research. What would you consider maybe the most important piece of work you've done in your career so far?

DR. GORDON: So far? You know, I really think it has to be one of two things. It's either -- and they're related, actually. It's the addressing minority groups in sizing and design.

When I did that 1988 survey, I did something very unusual for that. I oversampled all the minority groups in the Army so that I could actually estimate sample -- estimate sizing parameters, sizing design guidance for each of them separately and then overlay them and look to see how the shapes and sizes of different subgroups might be accidentally dis-accommodated in representative samples.

To have done that is probably the most -- the biggest contribution I've ever had. And it's probably also had the most impact.

DR. OHAB: Before we wrap up today's show, Dr. Gordon, is there anything else you'd like to add? DR. GORDON: Gosh, I'd just say that I really think that -- as you look around and sit in your car and put on your clothes and go shopping, think about those soldiers. Think about the soldiers and the fact that we have to fit them. We have to fit all of them. We have to fit them well. We have to protect them so they can protect us.

It's a terrific job. I'm really, really proud to be working a Natick and I thank you so much for the opportunity to tell you a little bit about my work.

DR. OHAB: Well, thank you for being here. Dr. Claire Gordon, senior scientist the U.S. Army Natick Soldier Research Develop and Engineering Center. It was a pleasure having you on "Armed with Science" today. And a pleasure having such an interesting discussion about anthropometry.

DR. GORDON: Thank you.

DR. OHAB: Listeners, you can tune into our next show, Wednesday, June 10th, when we are joined by Dr. Barbara Rothbaum. She's the director of the Trauma and Anxiety Recovery Program and the Emory School of Medicine. Dr. Rothbaum will discuss research investigating virtual reality exposure therapy as a treatment for post-traumatic stress disorder, PTSD, in Iraq servicemembers. Air Force mental health professionals are currently being trained to use this therapy, which involves recounting experiences out loud, while the therapist matches a virtual reality environment to the description.

We hope you enjoyed today's show. I'm Dr. John Ohab, and you have been scienced.

END.