Medical Xpress

Testing solutions to overheating in hazmat suits

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In 2015, health care workers in Kerry Town, Sierra Leone, contacted a Stanford research team regarding their work on how people regulate body temperature. They were hoping for a solution to the debilitating heat inside the gear that protected them from Ebola.

"During the previous Ebola epidemic, these workers read about our core body cooling technology on the web, and they asked whether we could do something for them," described Craig Heller, the Lorry I. Lokey/Business Wire professor of biology in the School of Humanities and Sciences. "In that hot environment and in their highly insulative personal protective gear, they could only work in the hot zone for 20-30 minutes before overheating."

Up to that point, Heller and Dennis Grahn, a senior research scientist, had created cooling systems for athletes that circulate cool water through a negative pressure glove to lower body temperature in between bouts of activity. They had also made cooling systems for bomb-sniffing dogs, who don't sniff when they are panting. But fitting their work under a sealed protective suit was a whole new challenge.

Since that initial inquiry, Heller and Grahn have been developing and testing a solution with help from students in their undergraduate course, "Human Physiology Laboratory." Altogether, the advances have roughly doubled the amount of time people can spend working in protective gear. The Heller lab is now engineering the final version of the cooling system that they plan to manufacture.

The recent Ebola outbreak in Congo highlights the urgency of this problem. When health workers overheat, it not only puts them in danger of heat-related illnesses like heat stroke, but it also compromises their mental and physical capabilities. Some have worried that an overheated worker might struggle to remove protective gear according to protocol, which, if done incorrectly, could expose them to the deadly virus.

Protective gear and treadmills

Our palms, the soles of our feet and our face act as the body's radiators. Under these skin surfaces lie blood vessels that, when open, can move a large amount of blood directly from the arteries to the veins. By controlling the flow of blood through that network of veins, the body can increase or decrease heat loss.

The new cooling system is made up of a small hydration backpack containing a frozen water bladder juxtaposed against a bladder of circulating fluid. Tubes coming from the backpack continuously feed that cooling fluid through pads inserted into the underside of fingerless gloves, extracting heat from the networks of veins in the palms. The system can work for four to six hours before the bladder needs to be refrozen.

To regulate the temperature of the glove, a valve mixes the warm returning fluid with cold fluid coming from the heat exchanger. Heller's previous data had suggested that water at about 15 to 16 degrees Celsius was most effective.

"If you get too cold, you have a reflex vasoconstriction – your blood vessels contract – which shuts down blood flow through these radiative structures and you get no heat transfer," said Grahn.

Suited up in protective gear similar to that worn by Ebola workers, the students tested how well the water system worked by walking briskly on treadmills at different slopes – some with the cool water perfusion system, some without. They could decide to stop exercising at any time but were required to stop when their heart rate reached 95 percent of their maximum, their core temperature hit 39 degrees Celsius or after 40 minutes – whichever came first. All this with a two-foot probe inserted through their mouth or nose to record their core temperature.

Under these laboratory conditions, the system at least doubled how long people could comfortably spend being active while wearing the protective gear. In some cases, it tripled and quadrupled their work time.

An important mission

In addition to this main experiment, teams of the students designed other experiments on thermoregulation in protective gear. At the end of the course, each team produced a video describing their experiments, which fulfills a Writing in the Major requirement. The class also helped continue Heller and Grahn's research on effects of heat extraction on physical conditioning of female athletes.

"Understanding the effects of cooling technology can not only benefit health care workers wearing personal protective equipment, but also many other professionals, including firefighters and athletes," said Christina Kohlmann BS '19, a student in the course. "It's ultimately a really great goal."

Getting this system into the hands of these professionals is the next step. Heller and his team are homing in on a manufacturable prototype but still need to figure out logistics, including how to produce and distribute the system on a larger scale. They are also continuing to study the effects of overheating on cognition.