Army study improves ability to predict drinking water needs

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When soldiers leave base for a 3-day mission, how much water should they bring? Military planners and others have long wrestled with that question, but new research from the *Journal of Applied Physiology* may now provide them an accurate answer.

The study substantially improves a water needs equation that the U.S. Army developed in 1982. That equation, known as the Shapiro equation, overestimates water needs.

The study produced formulations that are 58-65% more accurate than the Shapiro equation, at least in the laboratory. If the new formula works in the field, as expected, it could accurately predict water needs not only for soldiers, but also for civilians who work or exercise outdoors.

The study, "Expanded prediction equations of human sweat loss and water needs," appears in the online edition of the journal. The researchers are Richard R. Gonzalez, Samuel N. Cheuvront, Scott J. Montain, Daniel A. Goodman, Laurie A. Blanchard, Larry G. Berglund and Michael N. Sawka. The researchers are with the U.S. Army Research Institute of Environmental Medicine, except for Dr. Gonzalez, who is an adjunct professor at New Mexico State University. The American Physiological Society published the study.

Water needs difficult to predict

The Army spends substantial resources transporting water to troops in the field, including Afghanistan and Iraq. Water transport accounts for about one-third of in-theatre costs, according to Dr. Cheuvront. The Institute of Medicine has also expressed interest in improving the prediction of water needs for the general public and disaster relief efforts. Dr. Cheuvront points out that an improved sweating prediction equation would not only help keep troops healthy and cut the cost of operations, but would also facilitate better civilian water planning when desired.

The harder an individual exercises, the more oxygen he or she consumes and the more heat the body produces. Sweat is the body's coolant, but it only cools when it evaporates from the skin. When it is muggy out, the air is moist, slowing the sweat evaporation rate and reducing its cooling power.

Sweat rate and water needs are difficult to predict because water needs are so variable. Inactive individuals lose between one and three liters of body water a day. More activity and warmer climates can double or even triple ordinary losses. Sweat rates also vary depending on body size, exercise intensity, clothing, air temperature, humidity, wind, and even the individual's own genes.

The Shapiro equation, developed more than 25 years ago, is expressed as (msw (g•m-2•h-1) = 27.9 • Ereq • (Emax)-0.455, where:

- Ereq is evaporative heat loss required to maintain proper body temperature
- Emax is the evaporative potential of the environment
- msw represents sweat loss

- g•m-2 is grams of sweat multiplied by the body's surface area

The Shapiro equation needed to be:

- updated, to take into account new fabric in the clothing soldiers wear
- expanded, to predict water needs over long hours working outdoors
- refined, to make the predictions more accurate

In this study, the researchers collected data on 80 men and 21 women who exercised in the laboratory under varying conditions of work intensity and duration, environmental conditions such as temperature and humidity, and types of clothing. They measured the sweat losses for each volunteer and compared that to the sweat loss predicted by the equation. Once they were able to compare the prediction versus the real sweat rate, they derived specific algorithms statistically so that the predictions would more accurately reflect the observed sweat rates.

The study produced two equations. The researchers then cross validated the new equations, using new data from 21 men and 9 women. One of the equations increased the prediction accuracy by 58% and one increased accuracy by 65%. Either of these equations would provide predictions accurate enough to be used in the field, Dr. Cheuvront said.

"The new equations provide for more accurate sweat predictions over a broader range of conditions with applications to public heath, military, occupational and sports medicine settings," the authors wrote. The equation can be used in temperatures of 70-125° F, the same temperature range as the old equation, but now can predict sweat loss for up to eight hours of work, as opposed to two hours for the old formula.

Available to public?

As it stands, the equation would be difficult for members of the public to use. It contains many variables, reflecting the complexity of predicting sweat loss, such as skin temperature and amount of energy expended.

However, the researchers hope to develop either a table or an online application program in which an individual could enter variables such as height and weight, how hard and long they would be active and what the environmental conditions would be (temperature, humidity, sunlight and wind). The device would then calculate their sweat loss.

One variable the equation does not take into account is fitness levels, which do influence sweat rates. That may be the next area to work into the equation, Dr. Cheuvront said.

More information: jap.physiology.org/cgi/reprint … T=&author1=cheuvront %2C+s&searchid=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=HWCIT

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