Cool it!

Heat limits performance.

Heat stress forced Paula Radcliffe to drop out of the 2004 Olympic marathon. When the body's internal temperature is stressed by extreme heat, its homeostatic mechanisms may fail.

«A new world record!» These words convey the thrill of world-class athletic competition. But as records are broken by mere centimeters or by fractions of a second, are we reaching absolute limits to human performance? We can assess many physiological limits to extreme performance—maximum breathing rate, for example, or the maximum rate at which the heart can supply blood to the muscles. One less obvious physiological limit is temperature.

The 2004 Olympic women's marathon was held on a hot, humid day in Athens. World record holder Paula Radcliffe was the favorite in the 42-kilometer race. But, overcome by heat stress, Radcliffe collapsed 6 kilometers from the finish line. It could have been much worse. Heat stroke, which can occur when internal body temperature exceeds 41 °C, causes failure of major organs such as the heart and brain and results in death in over 20 percent of cases. Soldiers fighting in the desert are at extreme risk of heat-related illnesses, as are firefighters. Agricultural, industrial, and construction workers are also subject to the adverse affects of heat. Biologists at Stanford University developed a technology to cool individuals in such situations, and in the process discovered a way to enhance athletic performance.

Working muscles produce heat. This heat is carried by the blood to skin surfaces, where it is lost to the environment. Not all skin surfaces are equally good at dissipating heat, however. Because fur impedes heat loss, mammals evolved efficient bare skin heat-loss portals such as the nose, tongue, footpads, and parts of the face. These areas have specialized blood vessels that can act like radiators to disperse heat or close down to conserve heat. Although humans are not furred, we retain these specialized blood vessels in our hands, feet, and face (which is why we blush). The Stanford biologists designed a device to amplify heat extraction from these areas.

A cooling glove The heat extractor increases heat loss and allows the body to perform at a higher level in severe conditions.

The heat extractor is a chamber that encases the hand and is sealed at the wrist. The hand is in contact with a cooled surface, but the critical component is a mild vacuum produced inside the chamber. The vacuum pulls more blood into the hand, allowing the cool surface to extract more heat. With this device, an active individual's body temperature rises more slowly, and it cools more rapidly when they rest. An additional unexpected benefit is that cooling reduces fatigue and greatly increases exercise capacity. «Cooled» athletes work out harder and longer, and their physical conditioning increases substantially. In one study, college freshmen improved their pushup performance at a rate of 5 pushups a day without cooling, but 9 pushups a day with cooling. Some men and women in the study achieved more than 800 pushups in a workout session.

Human beings can survive in almost any terrestrial environment, from steamy tropical forests to frigid polar regions. Some of the ways we adapt to temperature are behavioral; our ability to control fire undoubtedly affected the course of our evolution. And, like all other mammals, we are adapted to maintain our internal temperature when confronted with heat or cold—an example of the need for living organisms to maintain a «steady state», or homeostasis.

Answer the questions

- Why Paula Radcliffe collapsed 6 kilometers from the finish line?
- What is the heat extractor?

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