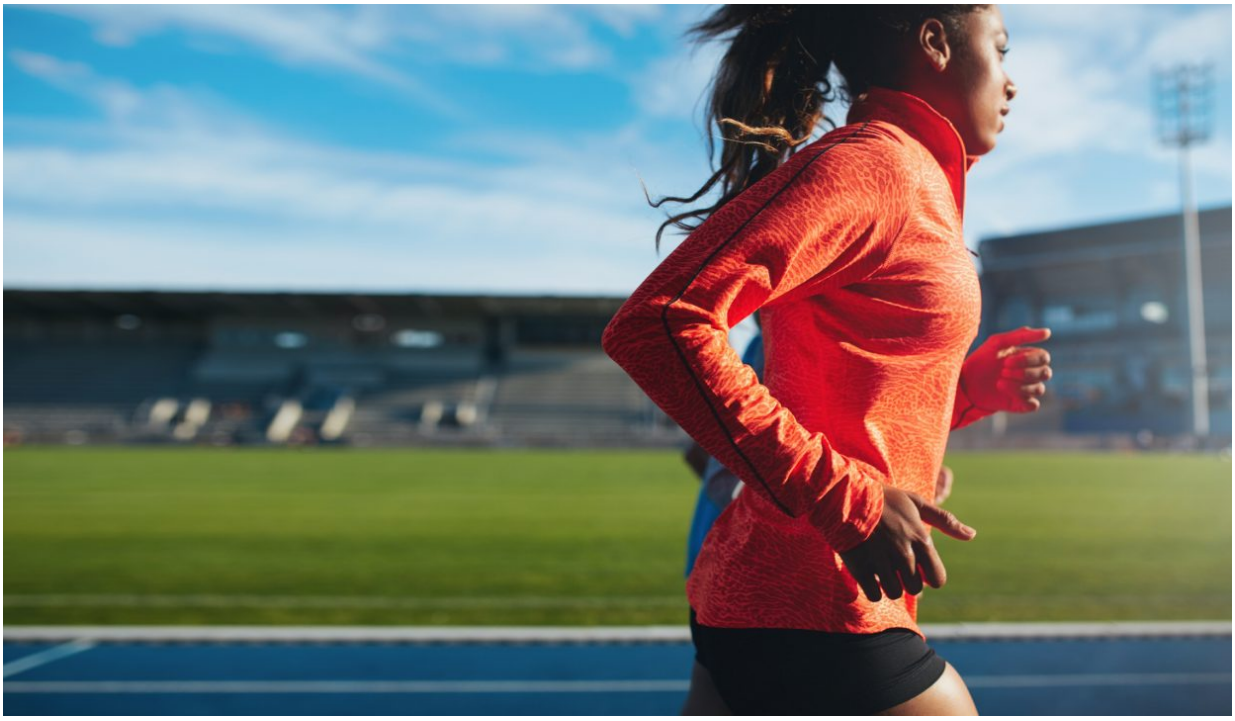
Amphetamine may slow rise of body temperature and mask fatigue to enhance endurance, study finds

November 29 2016, by Latina Emerson



Credit: Georgia State University

Amphetamine may slow down the rise of temperature in the body and mask fatigue, which could allow athletes to run significantly longer but result in potentially dangerous overheating of muscles, according to a study.

Researchers at Georgia State University and Indiana University have identified a new mechanism underlying the physical performance enhancement effect of amphetamine, providing new arguments about the potential danger of using psychostimulants to improve performance during exercise. The findings are published in the journal *Physiological Reports*.

The study found that rats treated with amphetamine (2 mg/kg) were able to run significantly longer on a treadmill than the control group. The researchers used a mathematical model to explain the amphetamine-induced changes in body temperature and calculate parameters that are difficult to measure experimentally. They suggest amphetamine may mask or delay fatigue by increasing heat dissipation (such as evaporative cooling through sweating in humans) and postponing when core body temperature exceeds the exhaustion threshold, which significantly increases muscle temperature by the end of the run and could pose health problems.

"Rats injected with amphetamine spent as much energy to run and processed oxygen the same as those that were not injected," said Dr. Yaroslav Molkov, associate professor in the Department of Mathematics and Statistics at Georgia State, previously of Indiana University-Purdue University Indianapolis. "But what was significantly different was their body temperature. In rats that received amphetamine, their body temperature was lower. When normal rats start running, their temperature starts rising and at some point when it hits a certain level, they stop. There's a very strong signal from the brain to not overheat. However, if the temperature increases more slowly, it hits the same level later and that's why rats treated with amphetamine are able to run longer.

"Using mathematical modeling, we were able to prove that what happens is they increase their heat exchange with the environment. Basically, they increase their heat dissipation. But while heat dissipates quicker from

the core body, it's not the same for muscles. Your body is tuned to know that if the core temperature, and hence, the muscle temperature reach certain levels, you should stop. But when you inject yourself with amphetamine, you don't know that anymore because your temperature control system is tricked and you think that it's not time to stop yet because your core temperature is not that high, even though your muscle temperature can already be dangerously high. I think this is one of the most important conclusions of this paper, that a seemingly innocent mechanism that accounts for better performance and durability actually turns out to be really dangerous as far as muscle overheating is concerned."

Exhaustion serves as an important safety mechanism to keep organisms from irreversible damage caused by intense exercise. Previous studies have shown that low to moderate doses of amphetamine increase the time until exhaustion. Amphetamine use is prohibited during competitions, but athletes may use amphetamine to improve their performance in some situations by delaying exhaustion. The mechanism by which amphetamine increases the time to exhaustion is unknown.

High body temperature is a major signal of exhaustion. During exercise, increased heat production in the muscles raises the temperature of muscles and the core body temperature. Regulatory heat dissipation mechanisms, such as vasodilation and evaporative cooling through sweating in humans, help remove heat and limit temperature growth during exercise. A balance between heat production and heat dissipation is crucial for keeping the temperature in different parts of the body in a safe range.

In this study, researchers wanted to investigate the effect of amphetamine on the thermoregulatory system. They measured core body temperature and oxygen consumption of rats (control group and amphetamine-treated group) running on a treadmill with incrementally

increasing speed and incline.

Rats treated with amphetamine (2 mg/kg) were able to run significantly longer than control rats. This amount of amphetamine slowed down temperature rise, decreasing core body temperature in the beginning of the run without affecting oxygen consumption. The control rats showed a steady increase in body temperature, and a lower dose of amphetamine (1 mg/kg) had no effect on core body temperature or oxygen consumption.

Researchers designed a mathematical model to estimate physiological parameters affected by amphetamine that are difficult to measure experimentally. Modeling revealed that administering amphetamine increases heat dissipation in the core and predicted that muscle temperature at the end of the run was significantly higher (almost one degree higher) for the amphetamine-treated group.

The researchers found the mechanism underlying the physical performance enhancement effect of amphetamine affects the thermoregulatory system and could result in potentially dangerous overheating of muscles. They conclude that while amphetamine improves endurance and extends the time at which exhaustion occurs, its use can result in health-threatening complications.

Provided by Georgia State University