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How Testosterone May Alter the Brain After Exercise

By GRETCHEN REYNOLDS

It's widely accepted among scientists that regular exercise transforms the brain, improving the ability to remember and think. And a growing and very appealing body of science has established that exercise spurs the creation of new brain cells, a process known as neurogenesis. But just how jogging or other workouts affect the structure of the brain has remained enigmatic, with many steps in the process unexplained.

A new study published last month in Proceedings of the National Academy of Sciences may fill in one piece of the puzzle, by showing that male sex hormones surge in the brain after exercise and could be helping to remodel the mind. The research was

conducted on young, healthy and exclusively male rats – but scientists believe it applies to female rats, too, as well as other mammals, including humans.

The decision to use only males was carefully considered. “We’ve known for a while that estrogen,” the female sex hormone, “is produced in the brain” not just of female animals but also, to some degree, in males, says Bruce S. McEwen, the director of the Laboratory of Neuroendocrinology at Rockefeller University in New York and an author of the study, which also involved scientists from the University of Tsukuba in Japan and other institutions. Estrogen has been well studied and has many effects, he said, including, scientists suspect, new brain cell growth.

But far less has been known about the role of male sex hormones in mammalian brains, particularly after exercise.

While both sexes produce male sex hormones, males produce far more of it – mostly in the gonads but, the researchers suspected, also in the brain.

The only way to know for sure if the hormones were being synthesized in the brain would be to shut off production in the testes, to guarantee that hormones from that site wouldn’t migrate to the brain. So some of the rats in the experiment were surgically castrated. The rest underwent a sham operation, in which nothing was removed. That procedure ensures that stress from the operation won’t skew results; all animals will have had the same unpleasant experience.

Separately, some of the animals also were injected with a drug that blocks the ability of male sex hormones to bind to receptors in the brain. Those animals might be able to produce the hormones, but they wouldn’t have any effects on the brain.

After recovery, most of the rats ran for two weeks on treadmills set at a leisurely jogging pace. Some remained sedentary.

Then the scientists examined all of the animals’ brains. They found that, compared with the sedentary animals, the running rats had significantly more of a potent testosterone derivative called dihydrotestosterone, or DHT, in their brains. Even the brains of rats that had been castrated sloshed with DHT.

So the exercise had prompted increased production of the hormone.

Most of the animals also had a plethora of new neurons in the hippocampus, a portion of the brain associated with learning and memory. Unexpectedly, however, the animals in this experiment that could not use the DHT in their brains did not experience enhanced neurogenesis. They exercised just as the other animals did, but their brains did not benefit in the same way.

This tells us that the uptake of DHT in the brain after exercise "appears to be a necessary step in achieving adult hippocampal neurogenesis," Dr. McEwen says.

In essence, exercise prompts the production of more DHT. And more DHT helps to create more new brain cells.

But while those findings may be salutary for men who are active and fit, or planning to become so, they seem potentially troubling for those of us without testes. If DHT is necessary for neurogenesis after exercise and women produce far less of it than men, do women gain less brain benefit from exercise than men?

"It's unlikely," Dr. McEwen says. One reason that early experiments into exercise and neurogenesis tended to be performed in female rats was that "in rats, females exercise more than the males," he said. "They'll run for hours and keep running, even when they're old." Elderly males, in contrast, willingly quit working out. In those experiments, neurogenesis was plentiful in the female brains.

"It's very probable that estrogen plays a role" like that of DHT in the female brain after exercise, Dr. McEwen says. Meanwhile, female brains also produce varying amounts of male hormones. So there may be some as-yet-undiscovered interactions between the male and female hormones in the brain that mesh after jogging to increase brain cell numbers and improve the ability to think.

But for the moment, the full effects of exercise and sex hormones on the brain are still being teased out.

But one aspect of the new experiment is already resoundingly clear and reassuring, Dr. McEwen points out. "The exercise in this experiment was quite mild," he says — the equivalent of jogging at a pace at which someone could speak (or squeak) to a companion. "That's achievable for most people," he concludes, "and the evidence suggests that it will improve brain health."